CHAPTER 2. PART 27
AIRWORTHINESS STANDARDS
NORMAL CATEGORY ROTORCRAFT

SUBPART D - DESIGN AND CONSTRUCTION

DESIGN AND CONSTRUCTION - GENERAL

AC 27.601. § 27.601 DESIGN.

a. Explanation.

(1) This rule requires that no design features or details be used that experience has shown to be hazardous or unreliable.

(2) Further, the rule requires that the suitability of each questionable design detail and part must be established by tests.

b. Procedures.

(1) This rule is met partially by a review of service history of earlier model rotorcraft, or for a new model, review of service experience of models with similar design features. Specifically, this rule covers "features or details" such as the following:

(i) Seat track-to-seat interface fittings. These fittings should have adequate locking devices to prevent both premature structural failure and premature unlatching.

(ii) Seat belt and harness should be of a type and construction that service experience has shown to be easy to don and unlatch and remove. They should also be of a type that is reliable, does not interfere with egress, and does not sustain unnecessary wear and tear under normal operations.

(iii) Metallic parts less than a certain thickness gauge and composite materials less than a certain number of plies should not be used. The minimum thickness and number of plies should be based to a large degree on service (normal wear and tear) experience with similar designs.

(2) The effects of service wear on the loading of critical components should be considered. Flight testing, ground testing, and analyses may be used in these considerations.

(3) Tests are required for details and parts which the applicant chooses to use after questions have arisen concerning their suitability.

AC 27.602 § 27.602 CRITICAL PARTS.

a. Explanation. The objective of identifying critical parts is to ensure that critical parts are controlled during design, manufacture, and throughout their service life so that the risk of failure in service is minimized by ensuring that the critical parts maintain the critical characteristics on which certification is based. Many rotorcraft manufacturers already have procedures in place within their companies for handling “critical parts”. These may be required by their dealings with other customers, frequently military (e.g., US DoD, UK MoD, Italian MoD). Although these programs may have slightly different definitions of “critical parts” and have sometimes been called “Flight Safety Parts”, “Critical Parts”, “Vital Parts”, or “Identifiable Parts”, they have in the past been accepted as meeting the intent of this requirement and providing the expected level of safety.

b. Procedures. The rotorcraft manufacturer should establish a Critical Parts Plan. The policies and procedures which constitute that plan should be such as to ensure that-

(1) All critical parts of the rotorcraft are identified by means of a failure assessment and a Critical Parts List is established. The use of the word “could” in paragraph 29.602(a) of the rule means that this failure assessment should consider the effect of flight regime (i.e., forward flight, hover, etc.). The operational environment need not be considered. With respect to this rule, the term “catastrophic” means the inability to conduct an autorotation to a safe landing, without exceptional piloting skills, assuming a suitable landing surface.

(2) Documentation draws the attention of the personnel involved in the design, manufacture, maintenance, inspection, and overhaul of a critical part to the special nature of the part and details the relevant special instructions. For example all drawings, work sheets, inspection documents, etc., could be prominently annotated with the words "Critical Part" or equivalent and the Instructions for Continued Airworthiness and Overhaul Manuals (if applicable) should clearly identify critical parts and include the needed maintenance and overhaul instructions. The documentation should:

(i) Contain comprehensive instructions for the maintenance, inspection and overhaul of critical parts and emphasize the importance of these special procedures;

(ii) Indicate to operators and overhaulers that unauthorized repairs or modifications to critical parts may have hazardous consequences;

(iii) Emphasize the need for careful handling and protection against damage or corrosion during maintenance, overhaul, storage, and transportation and accurate recording and control of service life (if applicable).

(iv) Require notification of the manufacturer of any unusual wear or deterioration of critical parts and the return of affected parts for investigation when appropriate;

(3) To the extent needed for control of critical characteristics, procedures and processes for manufacturing critical parts (including test articles) are defined (for example material source, forging procedures, machining operations and sequence, inspection techniques, and acceptance and rejection criteria). Procedures for changing these manufacturing procedures should also be established.

(4) Any changes to the manufacturing procedures, to the design of a critical part, to the approved operating environment, or to the design loading spectrum are evaluated to establish the effects, if any, on the fatigue evaluation of the part.

(5) Materials review procedures for critical parts (i.e. procedures for determining the disposition of parts having manufacturing errors or material flaws) are in accordance with paragraphs (3) and (4) above.

(6) Critical parts are identified as required, and relevant records relating to the identification are maintained such that it is possible to establish the manufacturing history of the individual parts or batches of parts.

(7) The critical characteristics of critical parts produced in whole or in part by suppliers are maintained.

AC 27.603. § 27.603 (Amendment 27-16) MATERIALS.

a. Explanation. The rule requires that the suitability and durability of materials, the failure of which could adversely affect safety, must be determined by three-fold considerations:

(1) Considerations based on experience or tests.

(2) By meeting approved specifications.

(3) By taking into account environmental conditions such as temperature and humidity.

b. Procedures.

(1) Where possible, materials that meet widely accepted specifications such as AISI, SAE, MIL, or AMS and alloys which have favorable experience or tests should be used. Where company developed materials are used, approved specifications are required to ensure the developed properties are duplicated in each lot of material.

(2) Environmental conditions may be taken into account by service experience, coupon testing, full-scale testing, or a combination of testing and experience, MIL-HDBK's -5, -17, and -23 include some environmental effects and contain reference to additional methods of testing for environmental effects.

(3) Section 27.613 concerns strength properties and design values. (See paragraph AC 27.613.)

AC 27.605. § 27.605 (Amendment 27-16) FABRICATION METHODS.

a. Explanation. The basic requirement of this rule is that the methods of fabrication must produce sound structure and produce it consistently.

(1) A process specification is required for fabrication processes requiring close control.

(2) A test program is explicitly required for each new aircraft fabrication method.

b. Procedures.

(1) The approved specifications required by this rule may either be established government/industry specifications such as MIL, AISI, ASIM, or SAE; or the specifications may be company-developed proprietary specifications. Sufficient data should be provided to the FAA/AUTHORITY aircraft engineering offices to show that the desired features are provided by the process specification. In addition, sufficient process controls, inspections, and tests should be coordinated with FAA/AUTHORITY manufacturing inspection personnel to ensure that continued quality of the process is provided.

(2) In addition to the examples given by the rule; i.e., gluing, spot welding, and heat treating process, specifications should also be prepared for types of welding other than spot welding, for platings of metals, for protective finishes (other than decorative), for sealing, and for unique fabrication methods such as those used for composite materials.

(3) The required test programs should consider static strength effects, fatigue strength effects, and environmental effects as appropriate to the processes.

AC 27.607. § 27.607 (Amendment 27-4) FASTENERS.

a. Explanation. Section 27.607 of Amendment 27-4 requires dual locking removable fasteners in critical locations. A nonfriction locking device is specifically required in any bolt subject to rotation, as stated in the rules.

b. Procedures. Advisory Circular 20-71 contains information, procedures, and means of complying with § 27.607 of Amendment 27-4.

AC 27.609. § 27.609 PROTECTION OF STRUCTURE.

a. Explanation. The structure should be suitably protected as specified in the rule to maintain its design strength. Ventilation and drainage provisions must be provided as specified in the rule. Overboard drains should be furnished for corrosive or waste liquids. Drains for flammable fluids are specified in other rules such as §§ 27.999 and 27.1193.

b. Procedures.

(1) The structure may be preserved, painted, or treated with chemical films to protect it from strength deterioration. An approved process specification should be used for these types of treatments.

(2) Parts may be plated or chemically treated, such as anodized, for protection. An evaluation and substantiation may be required to ensure the structure or parts are not adversely affected during, or as a result of, the plating or treatment process. (§ 27.605 concerns approval of process specifications and fabrication methods.)

(3) Plating or material surface hardness or composition changes may require fatigue substantiation to ensure the fatigue strength is not altered or is otherwise properly assessed. An approved process specification should be used for these types of treatments.

(4) To prevent water accumulation, drain holes should be placed at possible dams such as bulkheads and at low points in the fuselage and in the stabilizing surfaces.

(5) Control tubes and tubes used as primary mount structures (i.e., transmission support structure and engine mount structure) should be designed to prevent entry and collection of corrosive fluids or vapor, including water.

(i) A closed insert in each tube end may be used.

(ii) A sealant applied around the tube ends and around each rivet head may be used.

(6) Overboard drains should discharge clear of the entire rotorcraft. Dyed water discharged in flight may be used to ensure fluids are properly drained.

(7) Drains or vents which handle corrosive fumes (such as battery case vent line) may incorporate a container with an agent to neutralize the fumes prior to venting overboard.

(8) Welded tubes should be flushed and sealed after welding in accordance with an approved process specification.

(9) Refer to AC 43-4, “Corrosion Control for Aircraft,“ for further procedures.

AC 27.610. § 27.610 (Amendment 27-21) LIGHTNING PROTECTION.

a. Background. During the initial development and promulgation of the standards concerning the airworthiness of rotorcraft, it was not necessary to specify design features that would protect the rotorcraft from the meteorological phenomenon of lightning. This was due, in part, to the fact that rotorcraft were primarily operated in a VFR and nonicing environment. Also, a prudent pilot avoided thunderstorms where the possibility of encountering severe weather and a lightning strike was much greater. The construction, design, and operating environment of civil rotorcraft have changed markedly within the past two decades. Many rotorcraft are now authorized to fly IFR in all types of weather environment. One transport design has been approved for flight into known icing conditions. Additionally, many rotorcraft now use the same advanced technologies in structures and systems as do airplanes. Because of these facts, a specific rule on lightning protection of rotorcraft was adopted in Amendment 27-21. For further information, see the preamble of Amendment 27-21 (49 FR 44433; 11/6/84), Proposal 2-14. Section 27.610 is similar to § 25.581 which applies to the protection of structures of transport airplanes. However, the standard provides for specific protection of the aircraft structures as well as the systems of the rotorcraft. Section 27.610 is the standard referenced in the requirement for lightning protection of systems in § 27.1309(d) (see paragraph AC 27.1309). In addition, the protection of fuel systems from the effects of lightning is found and referenced in Report DOT/FAA/CT-83/3, User Manual for AC 20-53A, Protection of Airplane Fuel Systems Against Fuel Vapor Ignition Due to Lightning, dated April 12, 1985.

b. Explanation.

(1) The regulation requires that the rotorcraft must be protected against the catastrophic effects of lightning. This means that a lightning strike encounter should not prevent the continued safe operation of the rotorcraft.

(2) Paragraph AC 27.1309 addresses the protection required for systems. The protection of the rotorcraft structures may be accomplished in a similar fashion.

(3) The structural components of the rotorcraft should be designed in such a manner that the lightning current may be safely diverted or conducted through the rotorcraft without damaging any critical structure or without causing damage to noncritical structure, the failure of which would preclude the continued safe flight and landing of the rotorcraft. A radome or fin cap which explodes due to a lightning strike and results in catastrophic damage to main or tail rotors is a scenario of lightning damage to a noncritical structure which has catastrophic results.

(4) This type of strike effect on the rotorcraft is generally referred to as direct effects. Direct effects are damage which includes the burning, eroding, blasting, or structural deformation produced by the high currents of the lightning flash passing through the rotorcraft structure.

c. Procedures.

(1) Certification Plan. Although not a regulatory requirement, it is recommended that a formal written certification plan be used to assure regulatory compliance. The use of this plan is beneficial to both the applicant and the FAA/AUTHORITY because it identifies and defines an acceptable resolution to the critical issues early in the certification process. These are the usual steps to be followed when utilizing a certification plan:

(i) Prepare a certification plan which describes the analytical procedures and/or the qualification tests to be utilized to demonstrate protection effectiveness. Test proposals should describe the rotorcraft and system to be utilized, test drawing(s) as required, the method of installation that simulates the production installation, the lightning zone(s) applicable, the lightning simulation method(s), test voltage or current waveforms to be used, diagnostic methods, and the appropriate schedules and location(s) of proposed test(s).

NOTE: The recommended reference for quantification of the lightning environment, the determination of the aircraft lightning strike zones, and the determination of appropriate test methods is SAE AE4L Committee Report, dated June 20, 1978, Lightning Test Waveforms and Techniques for Aerospace Vehicles and Hardware. Additionally, information may also be found in the NASA publication No. RP-1008, Lightning Protection of Aircraft.

(ii) Obtain FAA/AUTHORITY concurrence that the certification plan is adequate.

(iii) Obtain FAA/AUTHORITY detail part conformity of the test articles and installation conformity of applicable portions of the test setup. Obtain FAA/AUTHORITY approval of the test proposal. A comprehensive test proposal may be used.

(iv) Schedule FAA/AUTHORITY witnessing of the test or tests proposed.

(v) Submit a test report describing all results and obtain FAA/AUTHORITY approval of each report prepared.

(2) Test Conditions. Refer to SAE AE4L Committee Report, dated June 20, 1978, and the NASA publication noted in paragraph c(1)(i) to determine the appropriate test parameters.

(3) Aircraft Design Features and Criteria. MIL-B-5087B, Amendment 2 or later amendment, contains valuable information to assist the designer. Figure 6 in the specification contains fault current versus bond resistance information. Refer to the NASA publication noted above also.

(i) Aluminum wire screen or mesh applied to the control or stabilizing surface and electrically bonded at each joint or juncture has been successful in conducting the current without serious damage.

(ii) Metal skin surfaces combined with surface wire screen or mesh have been successful. Also, successful use of surface treatment has been reported. For composites, treatments such as the following have been used: flame spray coatings, aluminized glass, metal foil, metallized fabrics, and conductive paint.

(iii) Ball or roller bearings may be used to conduct the current at rotating joints. However, increased friction or possible seizure of the bearing may occur. The potential for this should be evaluated. Inspection and replacement criteria for possible damage should be addressed in the manual for continued airworthiness. Bearings are especially susceptible to pitting and internal arcing.

(iv) Report DOT/FAA/CT-86/8, April 1987, Determination of Electrical Properties of Grounding, Bonding, and Fastening Techniques for Composite Materials, may assist the applicant.

(4) Fuel Systems. Refer to Report DOT/FAA/CT-83/3 referenced in paragraph AC 27.610a. For additional information on the lightning protection requirements for fuel systems for rotorcraft with a certification basis which includes Amendment 27-23 refer to paragraph AC 27.954.

AC 27.611. § 27.611 INSPECTION PROVISIONS.

a. Explanation. The rotorcraft must have access panels or openings that will allow for proper maintenance and/or adjustment of the rotorcraft systems.

(1) The rule states: “There must be means to allow close examination of each part that requires recurring inspection, adjustment for proper alignment and functioning, or lubrication.”

(2) “Structural” or load-carrying access panels may be used to comply with the rule. Structural panels should have stencils or permanent labels (§ 27.1541(a)(2)) stating the panels must be installed prior to ground or flight operation.

(3) Holes or “nonstructural” access panels should be used whenever possible.

b. Procedures.

(1) The determination of compliance can be accomplished in conjunction with the following activities:

(i) Reviewing type design drawings.

(ii) Conformity inspections accomplished during certification testing.

(iii) Be evaluated during the control system proof and operation tests (§§ 27.681 and 27.683).

(iv) During type inspection tests and functioning and reliability testing.

(2) Equipment requiring frequent inspections (at less than 25-hour intervals), lubrication, or adjustments should be accessible through "nonstructural" doors. Areas or items requiring daily attention should be accessible through "nonstructural" doors since properly rated maintenance personnel are required to "open and close" or reinstall structural panels, and special design features, such as multiple pins and latches, are generally necessary for structural doors.

AC 27.613. § 27.613 (Amendment 27-16) MATERIAL STRENGTH PROPERTIES AND DESIGN VALUES.

a. Explanation. The rule requires the use of materials that have a known minimum strength value. The structure must not be understrength and must be designed to minimize fatigue failure.

(1) Material design values in certain specified documents may be used. The FAA/AUTHORITY may approve other material design values thus allowing the applicant greater flexibility in selection of materials by proving their strength properties and design values as stated in § 27.613(d).

(2) Other materials that may be new or are not included in the specified documents may be tested and design values established as provided by § 27.613(a) and (d).

(3) Section 27.613(d) requires the selection of materials that will retain design values and properties in the type of service environment and for the length of service time intended for the structure.

(4) Section 27.613(c) is an objective rule concerning minimizing fatigue failures and § 27.571 concerns quantitative fatigue substantiation requirements.

b. Procedures.

(1) The properties and design values in the documents noted in the rule may be used.

(2) MIL-HDBK-5, Metallic Materials and Elements for Flight Vehicle Structure, Chapter 9, contains procedures for establishing design values of additional materials. Uniform means of presenting the data are also contained in this chapter.

(3) Design values and properties must include effects of the service environment and service time. An example is exposure at elevated temperatures on the ultimate tensile strength of 7079-T6 aluminum alloys as found in figure 3.7.4.1.1(c) of MIL-HDBK-5.

(4) The probability of disastrous fatigue failures must be minimized. This may be accomplished by using design features usually identified as fail-safe features, such as the following, which were obtained from Advisory Circular 20-95.

(i) Selection of materials with stress levels to provide a controlled slow rate of crack propagation combined with high residual strength after initiation of cracks (lightly loaded structures).

(ii) Use of multipath construction and the provision of crack stoppers to limit the growth of cracks.

(iii) Use of composite (multielement) duplicate structures so that a fatigue crack or failure occurring in one element of the composite (multielement) member will be confined to that element and the remaining structure will still possess adequate load-carrying ability.

(iv) Use of backup structure wherein one member carries all the load, with a second member available and capable of assuming the extra load if the primary member fails.

(v) Design to permit detection of cracks including the use of crack detection systems, in all critical structural elements before the cracks can become dangerous or result in appreciable strength loss, and to permit replacement or repair.

(5) Acceptable standards for pressurized containers or cylinders, such as cylinders of nitrogen, used to inflate emergency floats may be found in 49 CFR 178, Subpart C, §§ 178.36 through 178.68. Specifically, § 178.44 concerns standards for steel cylinders used in aircraft that are subjected to at least 900 PSI service pressure. This standard includes strength, test, material property, inspection, quality, design features, identification, and inspection report requirements. As an example, § 178.44-14, entitled “Hydrostatic Test,” requires that each cylinder must be (proof) tested to at least 5/3 times the service pressure. Section 178.44-16, entitled “Burst Test,” also states that one cylinder taken at random out of each lot of cylinders shall be hydrostatically tested to destruction.

(6) Other design criteria may be developed and approved under the provisions of FAR Part 27 as a unique part of the aircraft type design.

AC 27.613A. § 27.613 (Amendment 27-26) MATERIAL STRENGTH PROPERTIES AND DESIGN VALUES.

a. Explanation. Amendment 27-26 added explicit probability standards criteria to § 27.613(b). This amendment also provided for testing or proving the strength of selected individual items rather than conducting coupon tests to develop generic material strength properties that would be used for design purposes.

b. Procedures. The basic procedures of paragraph AC 27.613 still apply, except:

(1) Probability criteria common with MIL-HDBK-5D are explicitly allowed to determine strengths for metallic materials whose data are not available in MIL-HDBK-5D. These specific probability criteria should be used in conjunction with MIL-HDBK-17B whenever determining material strength properties for non-metallics. (Also, reference paragraph AC 27 MG 8).

(2) New § 27.613(e) provides for the premium selection of materials. The premium selection of materials method uses a specimen from each individual item (part) to determine its properties before its use is allowed. This is a highly specialized and possibly costly method which applies only to parts that have areas available from which specimens can be obtained without destroying the part. The rotorcraft type design data of those parts made from premium selection should have the necessary information, such as a minimum allowable strength, on the drawing.

AC 27.619. § 27.619 SPECIAL FACTORS.

a. Explanation.

(1) This is a general rule to complement other rules. Special factors are employed for reasons cited in the rule to ensure an airworthy aircraft structure. The 1.5 ultimate load factor in § 27.303 is multiplied by a special factor as specified in the rule.

(2) Specific factors are prescribed for castings and fittings in §§ 27.621 and 27.625, respectively. Factors may be prescribed for bearings with free clearance as stated in § 27.623. In addition, any other factor may be prescribed “to ensure that the probability of the part being understrength because of the uncertainties specified in § 27.619(a) is extremely remote.”

b. Procedures.

(1) One example of fitting factor use follows:

1,000-pound limit design load x 1.15 fitting factor x 1.5 ultimate load factor equals 1,725-pound ultimate design load.

(2) Other specific factors may be similarly applied. Refer to §§ 27.623 and 27.625.

(3) Other factors may be imposed as cited in the rule. Advisory Circular 20-107, paragraphs 5 and 6, are examples of requiring tests of component and subcomponent structure to account for variability of strength and stiffness of composite structures. Factors appropriate for the particular design are obtained and used in substantiation of the composite structure.

(4) The rule complements §§ 27.603 and 27.613. Regardless of the rule invoked, the variability of the material and/or assembly properties should be accounted for.

AC 27.621. <u>§ 27.621 CASTING FACTORS</u>.

a. <u>Explanation</u>. Casting design, test, and inspection criteria are included in this rule for critical and noncritical structural castings. Hydraulic or other fluid containers are not subjected to “structural loads” but are subject to pressure testing as a part of hydraulic or other flight systems. Critical and noncritical castings are defined in the rule.

(1) Factors, tests, and inspections are specified for structural castings. Additional factors, tests, and inspections may be applied, as prescribed by § 27.603, § 27.605, or § 27.613, for foundry quality control.

(2) For castings that have surfaces subject to bearing structural design loads, the casting factor need not exceed 1.25 with respect to bearing stresses and need not be used with respect to the bearing surfaces if the bearing factor of § 27.623 exceeds the applicable casting factor.

(3) Critical castings must have a casting factor not less than 1.25 and must receive 100 percent inspection as specified including radiographic inspection. Static test requirements are also specified in addition to the inspection requirements.

(4) Noncritical structural castings may have a casting factor as small as 1.0 with attendant increased inspection and quality control requirements. Use of larger casting factors reduces the inspection and quality control requirements.

(5) Structural static and fatigue substantiation, by test or analysis, is still required in addition to any casting static tests required by this rule.

b. <u>Procedures</u>.

(1) The rotorcraft castings should be classified as critical or noncritical or nonstructural or fluid container as soon as possible in the certification program. The applicant should then be prepared to propose the tests required for certification.

(2) The casting factors and associated inspection requirements dictated by § 27.621(c) and (d) are shown in the following chart:

INSPECTION REQUIREMENTS

	CRITICAL CASTINGS <(2)>		NONCRITICAL CASTINGS <(3)>	
CASTING FACTOR RANGE <(1)>	FAA REQUIRE-MENT 27.621(c)	OTHER CLASSIFICATION	FAA REQUIRE-MENT 27.621(d)	OTHER CLASSIFICATION
2.01 OR GREATER	<(7)>		<(4)>	
1.50 TO 2.00	<(7)>		<(5)>	
1.250 TO 1.499	<(7)> <(8)>		<(6)>	
1.00 TO 1.249	NOT ALLOWED	NOT ALLOWED	<(7)> <(8)> <(9)>	

<(1)> Ultimate load = Casting factor x 1.5 x limit load. CAUTION: For casting factor range of 1.25 to 1.5 see yield test requirements of NOTE <(8)>. The mechanical properties to be used for analysis shall be based on the tabulated values of MIL-HDBK-5 or other approved sources, ref. § 27.613.

<(2)> Critical castings are those castings whose failure would preclude continued safe flight and landing or result in injury to any occupant, ref. § 27.621(c).

<(3)> Noncritical castings are castings other than those defined by NOTE <(2)>.

<(4)> Each casting shall receive 100 percent visual inspection.

<(5)> Each casting shall receive 100 percent visual and reduced magnetic particle or penetrant inspection or approved equivalent methods.

<(6)> Each casting shall receive 100 percent visual and reduced radiographic and magnetic particle or penetrant inspection or approved equivalent methods.

<(7)> Each casting shall receive 100 percent inspection by visual, radiographic, and magnetic particle or penetrant inspections or approved equivalent methods.

<(8)> Three sample castings shall be static tested and shown to meet:

No failure at 1.25 x 1.5 x limit load, and
no yielding at 1.15 x limit load.

<(9)> Castings shall be procured to a specification that guarantees the mechanical properties of the material in the casting and provides demonstration of these properties by test of coupons cut from the castings on a sampling basis.

This chart may be included in the casting test proposal report. It is recommended that the applicant include in the test proposal report additional information such as shown in paragraph AC 27.621b(3).

(3) The casting test report may include the following sections or items in a Part I of the report. The report may also have a Part II that contains the test results as shown in the following example report. The following sections are a recommended format content of the report. Appropriate changes should be made as desired to accommodate the applicant’s system.

EXAMPLE OF REPORT
INTRODUCTION

This report presents the proposal for the static test of the castings used on the Model XYZ. The castings will be tested in compliance with Federal Aviation Regulations § 27.621. The purpose of this test is to substantiate the structural strength of the castings used on the Model XYZ. Part II of this report, which will be published after static tests have been completed, will present test results.

All test specimens will be selected as radiographic standards of acceptance for the particular castings (see Test Specimen). Additional information on selecting the specific castings may be included in the test specimen section of this report.

Load sheets giving direction and magnitude of loads for each of the castings are presented in numerical order by part number at the end of this report. The test loads and design criteria for the castings are discussed in detail in the test loads section of this report.

The test loads will be applied and reacted using mating aircraft parts or special fixtures which simulate the mating parts. The methods and apparatus to be used for the static tests of the castings are discussed in the apparatus and method section of this report.

Testing will be conducted in . . . (location).

TEST SPECIMEN

The castings which will be tested are listed in numerical order in figure AC 27.621-2. Those castings which, after structural analysis, show less than a 1.5 casting factor will be tested. All directions are given with reference to a forward facing position in the rotorcraft.

On the basis of a radiographic examination, the three castings which are of the poorest acceptable quality in the first production lot of castings will be selected as test specimens. The poorest of the three castings will be selected as the initial test casting and its radiograph or ASTM standard will be used as the standard for accepting future castings of the particular part unless later standards are approved. Three castings must be tested for each critical condition for each part.

Conformity Inspection

Each machined casting will be subjected to an FAA/AUTHORITY conformity inspection prior to testing to determine compliance with the type design drawings. A conformity report for each casting may be incorporated in Part II, Test Results, of this report.

The test specimen will be permanently marked or defaced after testing to preclude its use on a rotorcraft.

See figure AC 27.621-2 for an example of a convenient means of listing castings.

TEST LOAD

The test load(s) to be applied to each casting represents the critical loading condition(s) for that casting. The critical conditions on each of the castings were determined by the design criteria and substantiating data approved by the FAA/AUTHORITY.

The design criteria for all of the castings to be static tested may fall into one of two categories. The load factors and structural acceptability requirements for each category are discussed below. Casting factors that are included on the load sheets of each part do not apply in the discussion below. (See paragraph AC 27.621b(2) for casting factors.)

Castings Designed to Limit Load Conditions

A structural analysis of each test casting showing the critical design limit load conditions is given in the data (reference report number here). The load factors for the static test of the castings are as follows:

1.15 x design limit load = design yield load
1.50 x design limit load = design ultimate load

Castings Designed Only to Crash Landing Conditions

The castings in this category were designed using a crash landing load factor for the design ultimate load. The design yield load criteria of 1.15 x limit load need not apply to these castings. The test loads for these castings may be given in terms of design ultimate load on the individual casting load sheets shown in Part I of this report.

Test Procedures

Depending on the results of the initial static test of each casting, the following procedure will be used.

a. If in the initial test of critical castings the casting is found to have a casting factor of 1.5 (1.5 x design ultimate load), the casting will be considered acceptable and no further tests will be conducted.

b. If in the initial test(s) the critical casting is found to have a casting factor less than 1.5 but equal to or greater than 1.25, two additional castings will be tested for each critical load condition. Each must also show a minimum casting factor of 1.25.

c. If in the initial test, or in one of two additional tests, a casting shows a casting factor less than 1.25 times design ultimate or yields prior to reaching 1.15 times design limit load, the casting will be redesigned and retested. The yield criteria are also applicable to the first two procedures with the exception of critical castings designed to crash landing conditions.

TEST APPARATUS AND METHOD

The Model XYZ casting static tests will be conducted using fixtures designed to simulate the installation of the castings in the aircraft. Where practical, mating aircraft parts will be used to apply and react test loads. When practical, the static tests will be conducted with mating castings assembled when the critical loads for the mating castings are compatible; otherwise, fixtures simulating the mating parts may be designed and fabricated for the tests. Assembly hardware used to mount test castings will be the same as hardware used on the rotorcraft. All bolt torques and other assembly notes will conform to the type design assembly instructions.

The tests will be conducted using calibrated load measuring devices such as hydraulic cylinders and pressure gages, load cells, strain gage bridges, or dead weights.

Deflections of the casting may be measured using graduated dial indicators or scales in all tests. The deflection indicators will be based or mounted on the casting and will measure casting deflection only when possible; otherwise, the indicators will be based on the fixture and measure deflection of the casting relative to the fixture. Deflection readings will be made at 20 percent increments of limit load through 100 percent of limit load and at 115 percent of limit load. These increments may be changed if necessary. Permanent deformation readings will be made after relieving 115 percent and 150 percent of limit load.

See figure AC 27.621-1 as an example of a load sheet.

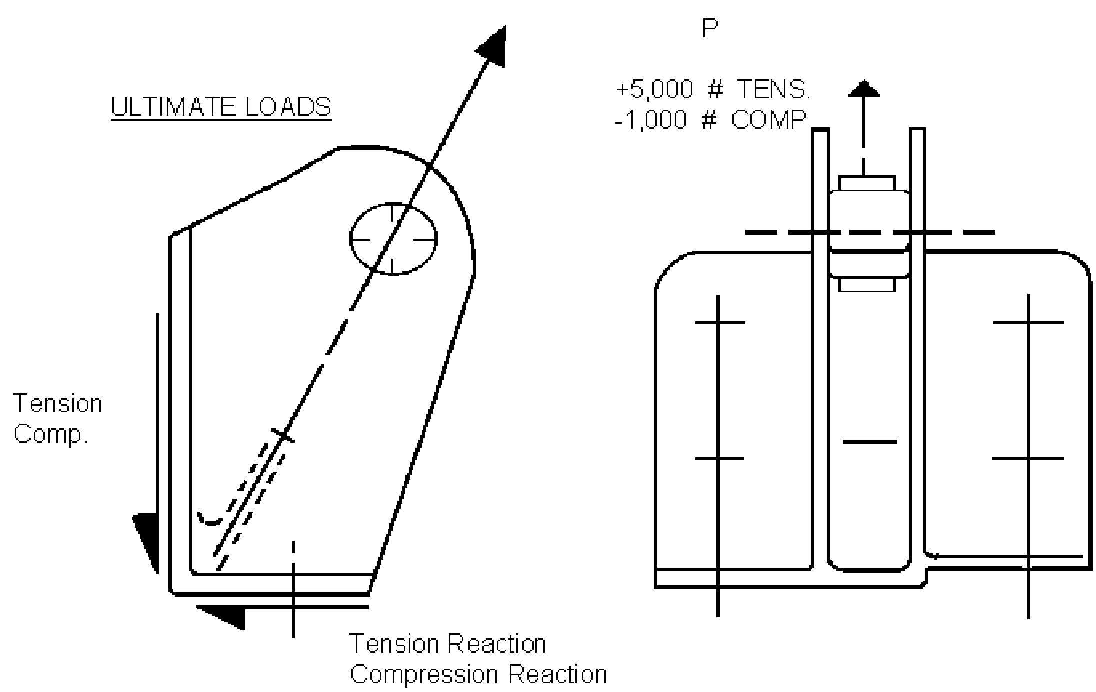

FIGURE AC 27.621-1
EXAMPLE OF CASTING LOAD SHEET
RETRACT ACTUATOR SUPPORT - LANDING GEAR

Include spherical bearing with clamped-up bolt and a link in the test setup to confirm the stability. Loads are based on a jam condition with actuator operating at 1,700 PSI pressure maximum.

A 1.25 casting factor is included in these loads.

These loads were derived from data in approved structural loads and analysis report.

END OF SAMPLE REPORT

(4) The format of the previous guidance material may be changed to accommodate the applicant's method of data presentation.

(5) Nonstructural castings may be tested and included in the test report.

(6) Cast fluid containers, including hydraulic fluid containers, may be tested as prescribed in other rules of FAR Part 27 and a test proposal and test results report may be included in the casting test report, or an appropriate report may be referenced for convenience. We recommend use of one report to contain test data or reference to test data for all castings used on the rotorcraft.

FIGURE AC 27.621-2 EXAMPLE

CASTINGS TO BE STATIC TESTED FOR MODEL XYZ

CASTING NO.	MACHINE OR ASSY. NO.	NAME AND LOCATION	MATERIAL	REF. LOAD SHEET FIG. NO.
		Base Assembly, Pilot's Collective Column		

AC 27.623. § 27.623 BEARING FACTORS.

a. Explanation.

(1) The rule requires use of a minimum bearing factor in free fit joints to account for effects of typical relative motion. A minimum value is not specified in the rule. The factor, appropriate for the application, is applied to the ultimate bearing strength of the softest material used as a bearing. A definition of free fit (clearance fit) is noted in paragraph AC 27.623b(7) below.

(2) A bearing factor, appropriate for the application, shall be used unless a larger factor is used.

(3) For reference, specific bearing factors are contained in § 29.685(e) for transport rotorcraft control system joints subject to angular rotation. These factors are applied to the ultimate bearing strength of the softest material used as a bearing in the control system. Control systems ball, roller, or needle bearings are covered by § 29.685(f) for transport rotorcraft.

(4) MIL-HDBK-5D, paragraph 8.3, refers to design standards for plan or journal bearings or bushings. These standards are found in Air Force Systems Command Design Handbook AFSC DH-2-1, Airframe, Chapters 3 and 6.

b. Procedures.

(1) Control system joint bearings are discussed under § 27.685 and paragraph AC 27.685A, but the bearing factors are noted here for convenience. For transport rotorcraft control systems, § 29.685(e) requires a 2.0 bearing factor for cable systems and a 3.33 bearing factor for push-pull systems other than ball and roller bearing systems. The manufacturer's static, non-Brinell rating of ball and roller bearings should not be exceeded. Use of this for normal category rotorcraft is recommended.

(2) A landing gear pivot, grease-lubricated, plain bearing is one example of a free fit subject to pounding or vibration. A bearing factor of 2.0 may be used or another factor may be proven for a grease-lubricated plain bearing or bushing to account for the anticipated higher loads caused by pounding or vibration. See paragraph AC 27.623b(6) for recommendations on ball or roller bearings.

(3) A typical engine mount bolt installation with a plain bearing having a free or loose fit (not interference fit) is another example of a sleeve bearing application subject to a design bearing factor. As an EXAMPLE OR ILLUSTRATION, a bearing factor of 1.85 may be applied to the design loads on the softest material reacting the bearing loads. A different but appropriate factor will be acceptable. The design limit load may be calculated for the example of a 0.312-inch-diameter bolt in a 2-inch-long bearing. The bearing projected area is 0.312 x 2 = 0.624-square-inches. The design limit load is 3,000 pounds. The design limit bearing stress is 3,000 pounds/0.624-square-inch x

1.85 = 8,894 PSI. If a free or loose fit is not used; i.e., tighter than free fit, a bearing factor is not required. See paragraph AC 27.623a(4) for bearing factors.

(4) Military standard part specifications, MS 21240, “Bearing, Sleeve Plain, TFE Lined,” and MS 21241, “Flanged Bearing, Sleeve Plain, TFE Lined,” contain allowable load ratings, static and dynamic, that apply to the particular use of the bearing. An appropriate bearing factor should be applied to the static rating. Military Specification (MIL-B-8943A, Amendment 3, “Bearing, Sleeve, Plain, and Flanged, TFE Lined” (temperature range -65° F to +250° F) shows that MS 21240 and MS 21241 sleeve bearings have been superseded by MS 1934/1 and MS 81934/2 sleeve bearings, respectively. Military Specification MIL-B-81934, Amendment 2, “Bearings, Sleeve, Plain and Flanged, Self-Lubricating,” uses TFE liners. These bearings are intended for use in a temperature range from -65° F to +325° F. Whenever a sleeve bearing is used, an appropriate bearing factor should be applied to the static rating that is contained in the specification or standard. Other sleeve bearings are contained in standards NAS 72 through NAS 77, NAS 537, and NAS 538. The installation design information is only contained in standards NAS 72 through NAS 74. These types of plain sleeve bearings are designed for clamping to the shaft or bolt with relative motion occurring on the bearing outside diameter. An appropriate bearing factor is required for the application.

(5) The minimum fitting factor 1.15, specified by § 27.625, must be applied as specified to account for load distribution at the fitting. This fitting factor need not apply to plain or journal “bearings” whose “bearing factor” exceeds 1.15.

(6) For airframe and landing gear structural joints, the manufacturer’s static, non-Brinell rating of ball and roller bearings should not be exceeded. ABEC Class 1 bearings or better quality bearings may be used in airframe structural joints and landing gear; ABEC Class 3, 5, or 7 bearings should be used in rotor pivot joints. The non-Brinell rating includes consideration of the bearing factor, and no other bearing factor is necessary.

(7) A free fit was described in American Standards Association (ASA) Standard B4a-1925. The “free fit” clearances and tolerances of this old standard are now called Class RC6, Medium Running Fit, in ASA Standard B4.1, 1955. As an illustration using these standards, a 1-inch diameter shaft and a plain sleeve bearing would have a clearance ranging from 0.0014 to 0.0040 inch.

AC 27.625. <u>§ 27.625 FITTING FACTORS</u>.

a. <u>Explanation</u>. A 1.15 factor is specified to ensure that the calculated load and stress distribution within any fitting is conservative. Application of the factor is excluded or is an exception as stated in the rule.

b. <u>Procedures</u>.

(1) The factor may be applied to the calculated load or stress for the fitting.

(2) The structural design substantiating data should include the fitting factor and where applicable should include, but not be limited to, the rotor system. The rotor system includes the rotor blade attachments, rotor head and hubs, and boosted control system elements. Other typical areas that may be considered are tail rotor gearbox attachment, tailboom to fuselage fittings, transmission pylon attachments, and landing gear attachment to the rotorcraft.

(3) The fitting factor is not required in the following applications:

(i) Joints such as continuous joints in metal plating, welded joints and scarf joints in wood.

(ii) Elements proven by limit or ultimate load tests such as nonboosted control system parts.

(iii) Elements for which a larger load factor is used such as a casting factor, a 1.33 retention factor when required for seats and safety belts, a fatigue factor, bearing factor or special factor greater than 1.15, crash load factors that are the only design case, and crash load factors that exceed limit load factors x 1.5 x 1.15.

(iv) Elements for which the failure mode does not affect safety of flight or occupant safety.

AC 27.629. § 27.629 FLUTTER.

a. Explanation. The rule requires that the rotorcraft “be free from flutter under each appropriate speed and power condition.”

b. Procedures. Freedom from flutter is to be shown for the entire rotorcraft with special attention to the blades, fins, and stabilizers.

(1) Flutter is defined as an aeroelastic instability resulting primarily from coupling of flap and pitch bending modes.

(2) Freedom from flutter may be shown by analysis or by appropriately instrumented flight flutter tests.

(3) The flight load survey proposal submitted for compliance with § 27.571 may also contain tests to fulfill compliance with § 27.629.

(4) Flight loads survey data or flight flutter test data should be reviewed to ensure that excessive oscillatory deflections of rotors or surfaces will not be encountered.

(5) Sensitivity analyses should be conducted to ensure that normal wear in the pitch change mechanisms of the main rotor blades and tail rotor blades does not reduce the effective stiffnesses sufficiently to cause flutter.

SUBPART D - DESIGN AND CONSTRUCTION

ROTORS

AC 27.653 § 27.653 (Amendment 27-2) PRESSURE VENTING AND DRAINAGE OF ROTOR BLADES.

a. Explanation. The rule requires each rotor blade to be provided with venting and drainage means (i.e., holes, etc.) or else the blade must be sealed and designed to withstand internal pressure.

b. Procedures. Although the rule provides for venting and drainage features, recently certificated blades have been designed to be sealed and to sustain the “maximum pressure differentials expected in service.” For modern blade designs, the internal pressure buildup due to environmental effects and centrifugal acceleration effects (near the tip) can be readily sustained with moisture sealing accomplished. The use of sealed blades is highly advantageous and recommended because of the possibility for severe corrosion damage resulting from trapped moisture and because of the difficulty in finding internal corrosion damage by use of field level inspections.

AC 27.659 § 27.659 (Amendment 27-2) MASS BALANCE.

a. Explanation. The rule requires that mass balancing of rotors and blades be provided, as necessary, to prevent excessive vibration and flutter. Further, the rule requires structural substantiation of the mass balance installation.

b. Procedures.

(1) The weight, geometry, and location of rotor and blade mass balance devices are determined as the requirements of §§ 27.571 and 27.629 are met.

(2) The structural substantiation should show static strength to meet the maneuver and gust loads of §§ 27.337, 27.339, and 27.341. In addition, the main rotor loads of § 27.547(c) should be substantiated. The fatigue strength of the mass balance devices (including structural supports) should meet the requirements of § 27.571.

(3) In addition to the appropriate strength requirements, some recent designs have included features which trap the balance weight inside a limited area even if the primary attachment means (adhesive, bolts, etc.) fail. This type of design feature is recommended because of the severe loading environment to which balance devices are subjected.

AC 27.661 § 27.661 (through Amendment 29-2) ROTOR BLADE CLEARANCE.

a. Explanation.

(1) This paragraph discusses the regulatory requirement contained in § 27.661. That requirement is that there must be enough clearance between the rotor blades (main and tail rotor blades) and other parts of the structure to prevent the blades from striking any part of the structure during any operating condition.

(2) In the past, some rotorcraft that have been shown to comply with § 27.661 during the certification process have experienced subsequent accidents involving in-flight contact between the main rotor and airframe (rotor/airframe contact). Completion of developmental and TIA flight testing without a rotor/airframe contact incident has proven not to be adequate demonstration of compliance with § 27.661 in all cases.

(3) Historically, in-flight rotor/airframe contact accidents have occurred as a result of mast bumping, rotor stall, or excessive rotor flapping due to control manipulation. For some rotorcraft, a more thorough examination may be required to ensure adequate clearances.

b. Procedures. Testing should be conducted by the applicant, prior to FAA/AUTHORITY participation, to ensure that the rotorcraft is in compliance with § 27.661 in all areas of the envelope during all operational maneuvers expected throughout the life of the aircraft. The tests should be performed concurrently with performance, flight characteristics, and flight loads testing. Tests should include:

(1) A blade flapping survey to determine flapping angles/margins, blade bending, and blade clearance from the entire airframe. Data may be gathered from instrumented flapping hinges, instrumented blades, high-speed video from airframe mounted cameras, a chase aircraft, or other acceptable means.

(2) Determine that margin exists between the minimum rotor RPM encountered during testing for compliance with § 27.143(d) and the RPM (power off) at which analysis shows that the rotor will experience a significant stall. A significant stall condition may be defined by the rotor reaching an RPM from which normal operating RPM is unrecoverable due to drag on the main rotor blades or, a stall that results in excessive main rotor flapping. The rotor RPM decay rate under the critical conditions of weight, density altitude, minimum approved power-on rotor RPM must provide a margin between the minimum rotor speed achieved during demonstration of compliance with §§ 27.79 and 27.143(d) and the analytically derived rotor stall RPM for the same conditions. For example, the minimum rotor RPM resulting during H-V tests must allow for a margin above the rotor stall value to allow for variations that may occur during operational flying.

(3) During parts of the certification flight test program, frangible devices (wood dowels) or other means of measuring clearance, may be requested to confirm that the clearances shown in the drawings and verified during company flight tests are adequate in all operating conditions. Balsa wood dowels or styrofoam pads may be clamped to the aft part of the fuselage and cabin roof within the rotor arc. Such devices may be

especially helpful in determining clearance during autorotation and controllability testing under FAR 27.143. If such measuring devices are used, the type inspection report should contain a record of clearance found during the tests. During TIA flight testing, it is not necessary to precisely determine the clearance but only necessary to determine "enough clearance" as stated in the rule.

AC 27.663 § 27.663 (Amendment 27-2) GROUND RESONANCE PREVENTION MEANS.

a. Explanation.

(1) This rule, adopted in Amendment 27-2 and revised in Amendment 27-26 requires reliability and damping action investigation for the ground resonance prevention means. The probable range of variations in service, not just the allowable range, must be established and investigated as prescribed. This probable range includes operation on the ground, and other appropriate landing surfaces applicable to the rotorcraft design shall be considered. Quantitative test data are generally obtained in compliance with this rule, but analysis or tests may be used.

(2) Appropriate maintenance information should be included in the maintenance manual (also called instructions for continued airworthiness).

(3) Paragraph AC 27.241 of this document concerns demonstrating freedom from ground resonance during certain applicant and TIA verification evaluations or tests of the rotorcraft. Section 27.241 complements the requirements of § 27.663. As noted in paragraph AC 27.241 of this document, a specific requirement for a ground vibration survey was removed from CAR Part 6. However Section 27.663 was adopted by Amendment 27-2 to investigate possible sources of ground resonance and to assure the reliability of the ground resonance prevention means, i.e., dampers, if necessary, to preclude occurrence of ground resonance. The total rotorcraft system is evaluated under this rule.

(4) Viscous dampers have been used for many years to prevent ground resonance. Modern rotorcraft designs may also use elastomeric dampers and may use elastomeric bearings in the rotor head and rotor pylon attachment to the airframe. The rule also requires investigation of the probable range of variations of these dampers, whether viscous or elastomeric, and these bearings to preclude ground resonance.

(5) Ground resonance can occur due to flexibility in the rotor pylon restraint system as well as with landing gear flexibilities. See paragraph b(2) of this guidance section (AC 27.663) for an explanation. An analysis may be done to show the effect of the rotor pylon mount stiffness on ground resonance stability. If the analysis shows that rotor pylon mount stiffness could affect ground resonance, the evaluation should include variations in stiffness and damping of the rotor pylon restraints that may occur in service (reference “Ground Vibrations of Helicopters,” M.L. Deutsch, JAS, Vol. 13, No. 5, May 1946).

b. Procedures.

(1) The reliability of the means for preventing ground resonance may be substantiated as stated in the rule. An analysis report or a test proposal and subsequent test report may be used to show compliance. The probable ranges of damping restriction are an important part of the assessment. The test may be conducted in conjunction with the testing required by § 27.241. See paragraph AC 27.241.

(i) Analysis and tests may be used.

(ii) Reliable service history of identical or closely similar systems may be used. The materials and fluids used, clearance or fits, seals, and physical installation are important items to be evaluated and considered for "closely similar" systems.

(iii) Testing of the complete rotorcraft may be used to prove that malfunction of a single means or member of the damping system will not cause ground resonance. One method of demonstrating acceptable compliance is by removing all or most of the fluid from a damper and considering the allowable ranges of damping of the other parts of the rotorcraft damping system while operating the rotorcraft throughout the rotor speed range from start to maximum rotor speed. Investigation of elastomeric dampers may require innovative test procedures and preliminary discussions of these prior to preparation of a test proposal. The rotorcraft cyclic control should be displaced as noted in paragraph AC 27.241 of this document to assure that the possible rotorcraft resonance frequencies are excited. If vibrations are damped in all tests, the damping system is satisfactory. Each critical rotor damper and landing gear damper must simulate a malfunction to comply with the rule. The testing discussed, however, could be come very extensive if one were to attempt to test all combinations of all maintenance adjustments of all components which contribute to the prevention of ground resonance, while at the same time rendering each of the pertinent components ineffective in turn and then repeating all of the maintenance tolerance testing each time. Fortunately, rational analytical methods are available which will permit the evaluation of such combinations so that only the combinations with the least amount of margin used are physically tested.

(2) The pylon damper variation can affect ground resonance. The variations in stiffness and/or damping of pylon mounts should be evaluated except the pylon mounts on contemporary conventional rotorcraft may have little influence on "classical" ground resonance stability. The dynamics of the rotorcraft on its landing gear is generally established by the airframe properties and the landing gear properties under the influence of the rotor system, with the "pylon" having little or no effect. For air or flight resonance, the rotor generally couples with the rigid body modes of the fuselage. For a specific design, a relatively simple analysis may be used to show the effect of the pylon mount system stiffness on air and ground resonance stability, and if not important, variations in the system may be omitted from the test program.

(3) The probable ranges of damping must be established and investigated as prescribed and noted in paragraph AC 27.663(b). An approved test proposal and test results report should be used for complying with § 27.663(b). If wheel landing gear is used on the rotorcraft, the probable ranges of tire pressure or the lowest probable tire pressure should be stated in the test proposal and effects of the tire pressure investigated during the test. See paragraph AC 27.241, § 27.241, concerning tests and instrumentation of the test associated with complying with § 27.241. The instrumentation noted in paragraph AC 27.241 also applies to § 27.663(b).

(4) If the wheel landing gear is equipped with wheel brakes, the evaluation should include brakes "on" and "off." The nose or tail wheel should be locked and unlocked if it swivels to evaluate any possible adverse effects of this feature.

(5) Any maintenance procedures should be included in the "recommended" part of that manual. See Appendix A, FAR Part 27.

AC 27.663A <u>§ 27.663 (Amendment 27-26) GROUND RESONANCE PREVENTION MEANS</u>.

a. <u>Explanation</u>. Amendment 27-26 clarifies that analysis as well as tests may be used to show freedom from ground resonance after malfunction or failure of a single means of ground resonance prevention. This amendment primarily clarifies that the probable range of damping should be established as well as investigated.

b. <u>Procedures</u>. The procedures of paragraph AC 27.663 continue to apply with the addition of the need to document the establishment of the probable range of damping of ground resonance prevention means. Acceptable tire and oleo minimum and maximum pressures as well as other identified factors should be documented in maintenance instructions if necessary to maintain the desired characteristics.

SUBPART D - DESIGN AND CONSTRUCTION

CONTROL SYSTEMS

AC 27.671. § 27.671 CONTROL SYSTEMS --GENERAL.

a. Explanation.

(1) The rule requires basically that controls operate easily and smoothly and provide positive response of the rotorcraft from control input.

(2) In addition, the rule requires that incorrect assembly be prevented by special design features or special markings.

b. Procedures.

(1) Easy, smooth operations of controls are substantiated by the operations tests of § 27.683 and the FAA/AUTHORITY flight testing under TIA procedures. Positive response of the rotorcraft to control inputs is also evaluated during company flight testing and FAA/AUTHORITY TIA flight testing to the requirements of §§ 27.141 through 27.175.

(2) To meet the requirement that incorrect assembly be prevented, the preferred method is providing design features which make incorrect assembly impossible. Typical design features which can be used are different lug thicknesses, different member lengths, or significantly different configurations for each system component. In the event that incorrect assembly is physically possible (because of other considerations), the rule may be met by the use of permanent, obvious, and simple markings. Permanent (durable) decals or stencils may be used.

(3) Design features of the control systems are checked when reviewing the type design drawings. During the proof and operation tests of §§ 27.681 and 27.683, the controls should be thoroughly reviewed for possible incorrect assembly and for any required markings supplied for compliance with this standard.

AC 27.672. § 27.672 (Amendment 27-21) STABILITY AUGMENTATION, AUTOMATIC, AND POWER-OPERATED SYSTEMS.

a. Explanation.

(1) This rule requires that the pilot be made aware of stability augmentation, automatic, or power-operated system failures which could lead to an unsafe condition. Examples of clearly distinguishable warnings include, but are not limited to, an obvious aircraft attitude change following the failure or an audio warning tone. A visual indication itself may not be adequate since detection of a visual warning would normally

require special pilot attention. The use of devices such as stick pushers or shakers is not acceptable as a warning means. However, this rule is not intended to eliminate the use of such devices for other purposes. Examples of automatic control systems other than a stability augmentation system would be a pitch axis actuator used for the purpose of demonstrating compliance with longitudinal static stability requirements or a fly-by-wire elevator. For control systems where a series actuator malfunction could degrade control authority, a means should be provided to the pilot to determine actuator alignment (see § 27.1329(b)).

(2) The corrective flight control input following a system failure should be in the logical direction. For example, a malfunction resulting in a nosedown pitch of the aircraft should require a corrective cyclic control input in the aft direction. The system deactivating means does not have to be located on the primary flight control grips; however, it should be easily accessible to the pilot. Malfunctions and subsequent recoveries must be shown throughout the operating envelope of the aircraft. In a case where control authority is decreased following a malfunction, a reasonable flight envelope must be defined wherein compliance with controllability and maneuverability requirements can be demonstrated. This reduced flight envelope must be presented in the flight manual. Compliance with trim and stability characteristics is not required following a malfunction; however, a pilot workload assessment should be made to show that a mission can be safely continued to completion following the worst case single failure.

b. Procedures. A discussion of malfunction test procedures is presented in paragraph AC 27 Appendix B b(6). Controllability and maneuverability test procedures are addressed in paragraph AC 27.143.

AC 27.673. § 27.673 (Amendment 27-21) PRIMARY FLIGHT CONTROL.

a. Explanation. This regulation basically defines primary flight controls as “those used by the pilot for immediate control of pitch, roll, yaw, and vertical motion of the rotorcraft.” This regulation was generated to clarify the application of § 27.1555 which requires markings for controls other than “primary flight controls or control(s) whose function is obvious.”

b. Procedures. The primary flight controls; i.e., cyclic stick, collective, and tail rotor pitch control pedals are excluded from the marking requirements of § 27.1555.

AC 27.674. § 27.674 (Amendment 27-26) INTERCONNECTED CONTROLS.

a. Explanation. A new § 27.674 is added by Amendment 27-26 which requires that the rotorcraft be capable of safe flight and landing after a malfunction, failure, or jam of any auxiliary interconnected control.

b. Procedures.

(1) Section 27.674 requires that the rotorcraft be shown to be capable of safe flight and landing after a malfunction, failure, or jam of an auxiliary control interconnected with a primary control. The section does not apply to interconnected primary controls; e.g., cyclic and collective controls.

(2) Examples of auxiliary controls covered by this section may include certain autopilot or stability augmentation or trim system components. Section 27.1309 methods may be used in determining failure effects of autopilot and stability augmentation “system” components. For components whose purposes are solely mechanical functions, the procedures associated with § 27.571 for components such as the main rotor may be used.

(3) If an engine control could jam and result in a collective control jam, the controls should be designed to relieve that connection.

AC 27.675. § 27.675 (Amendment 27-16) STOPS.

a. Explanation.

(1) Stops are required to prevent unrestrained movements of pilot/autopilot inputs from causing interferences or overloads.

(2) The rule requires that the stop must be located to not appreciably affect the control system range of travel due to wear, slackness, or take-up adjustments.

(3) Each stop is required to withstand loads corresponding to design conditions.

(4) In addition, each main rotor blade, if appropriate for the design, must have stops to limit its travel about its hinge points. For rotors with hingeless design, stops may be provided as appropriate to limit blade travel. Loads which result from the blade hitting the stops (during starting or stopping the rotor or during any large but allowable pilot control inputs such as autorotation cyclic flares or when subjected to ground gusts, etc.) shall not overload the stops nor any rotor component.

b. Procedures.

(1) Stops are generally provided in the cockpit area and near any controllable surface end of the control system (i.e., main rotor hub, tail rotor hub, and stabilizer activators). For systems with control coupling or series actuators, stops have been located farther downstream (away from the cockpit) to permit increased control output during malfunction (hardover) or extreme control position cases.

(2) Location of stops in close proximity to each end of a control system will allow the stop to provide its function most efficiently without undue deflections between the stop and its adjacent surface or its adjacent cockpit control lever or pedals. The location of stops close to the control lever or surface will help meet the requirement that

the stop (and its function) not be appreciably affected by wear, slackness, or take-up adjustments. Consideration should be given to limiting the total amount of take-up adjustments of both the stop and the control systems to preclude a hazardous adjustment of the control surface range of travel by either normal or extreme take-up adjustment.

(3) Each stop is to be substantiated for critical design conditions from either pilot effort, aerodynamic loads, hydraulic loads, and other critical loads, as applicable. The stops can be substantiated for limit loads by the tests of § 27.681.

(4) The stops to limit the main rotor blade about its hinge points should be positioned to prevent the blades from striking any part of the structure, particularly during startup and shutdown operations. These stops should also limit the flapping of the static main rotor blades of the rotorcraft when they are subjected to ground gusts and rotor wash from nearby taxiing rotorcraft. Provisions should be made to prevent overloading the stops or the blade under conditions of ground gusts and rotor wash effects or during autorotational landing flares. The need for provisions to prevent possible overloads due to ground gusts and close taxiing by adjacent rotorcraft and by autorotational landing can be determined using the instrumented flight load survey aircraft by hover-taxiing another rotorcraft near the instrumented aircraft and by conducting autorotational landing flares with the instrumented aircraft. Substantiation for the final main rotor flapping stop design can be demonstrated by similar tests.

(5) If features of design are added to the main rotor stop assembly which activate certain portions of the stop assembly only on the ground to meet the requirement that the blade not hit the droop stop during any operation other than starting and stopping the rotor, such features of design must be substantiated to reliably operate by both ground tests and flight tests, as appropriate. Wear and rigging tolerances should be considered in these demonstration tests.

AC 27.679. § 27.679 CONTROL SYSTEM LOCKS.

a. Explanation. The rule requires that if control system locks are provided, means are necessary to prevent the rotorcraft from taking off with the locks engaged or, once airborne, to prevent the locks from engaging in flight.

b. Procedures. Two main procedures may be used to meet the requirements of this rule.

(1) The first procedure is to provide a means to disengage the lock "automatically" as the pilot operates the controls. If this method is used, the means must disengage the lock in a manner that it will not automatically re-engage during flight under normal pilot operations. The means may be physical removal of the locking device from close proximity to the control system interface with deliberate crew action necessary to return the device to the control system interface, or the means may be that the mechanism geometry and/or actions prevent locks from engaging in flight.

(2) The second procedure which may be used is to provide locks which so limit rotorcraft operations that it is impossible to take off with the locks engaged. Acceptable means are features which prevent engine startup or which restrict collective control operations to prevent sufficient lift for takeoff.

AC 27.681. § 27.681 LIMIT LOAD STATIC TESTS.

a. Explanation.

(1) The rule requires static tests of the control system in showing compliance with limit load requirements.

(2) The tests are specified to include each fitting, pulley, and bracket of the control system being tested and to include the "most severe loading."

(3) Also, the rule requires that compliance with bearing factors (reference § 27.623) be shown by individual tests or by analyses for control system joints subject to motion.

b. Procedures.

(1) Compliance with the requirements of this rule is obtained by static tests conducted on either a static test airframe or on a prototype flying ship. In either case, conformity of the control system and related airframe is necessary to validate the tests.

(2) The rotor blades or aerodynamic surfaces may be used to react pilot effort loads through the control system, or they may be replaced with fixtures. If fixtures are used, they should be evaluated for geometric and stiffness efforts to ensure test validity.

(3) The loads to be applied during the limit load static tests are specified in §§ 27.395, 27.397, and 27.399. The loads are applicable to collective, cyclic, yaw, and rotor blade control systems as well as any other flight control systems provided by the design.

(4) Although Part 27 does not explicitly specify the bearing factors to be used in control system rotating joint tests or analyses, the factors of § 29.685 have been used in past programs. These factors are 3.33 for push-pull systems and 2.0 for cable systems for joints with plain bearings and manufacturers' ratings for ball and roller bearings.

AC 27.683. § 27.683 OPERATION TESTS.

a. Explanation. The rule requires that the control system be free from jamming, excessive friction, and excessive deflection. An operational test is required in which specified loads are applied at the pilot controls and carried through an operating control system.

b. Procedures.

(1) Compliance with the requirements of this rule is obtained by use of a test setup similar to that used for the limit load tests of § 27.681, except the load reactions at the blades (or surfaces) must allow for movement of the blades (or surfaces) as the system is operated through its operating range.

(2) Fixtures are normally affixed to the surfaces (or replace the surfaces) to allow pulley arrangements which provide for movement under load. These fixtures should be evaluated to ensure that system loads up to limit will be applied during the full range of operations of each system.

(3) Each flight control system should be operated through its entire range under a light load and under limit load. As the controls are being operated, the system should be checked for jamming, excessive friction, and excessive deflection. Excessive deflection includes deflection sufficient to contact other systems or structures. Also (in agreement with CAM 04.331/04.43.11), FAA/AUTHORITY policy has been to consider excessive the deflection of a control system under limit load which exceeds approximately one-half of the system travel from neutral to the extreme stop. Floor panels, wall panels, and other access panels may have to be removed to permit visual checks of the entire control system.

AC 27.685. § 27.685 (Amendment 27-11) CONTROL SYSTEM DETAILS.

a. Explanation. The rule requires that the control system be designed to prevent chafing, jamming, and interference from cargo, passengers, loose objects, or the freezing of moisture. Specifically, means are required in the cockpit to prevent the entry of foreign objects into places where they would jam the system, and means are required to prevent the slapping of cables or tubes against other parts.

b. Procedures.

(1) The geometry of the control system components and their installations are the primary control to prevent chafing, jamming, and interference. The control system from cockpit to surface should be checked for clearances both unloaded and loaded. The control system should be checked under load during both the limit load static tests (reference § 27.681) and the operational tests of § 27.683. Location of guides or fairleads and pulleys may be used in cable systems to prevent chafing and interference with other structure. Generally, tubes should clear adjacent structure by location and design geometrical considerations. If supplemental means are provided to assure the tubes do not chafe or interfere, the means should be evaluated for possible jamming.

(2) Rubber (or other elastomeric) boots connected to both the cockpit control arm or shaft and to the floor are acceptable means to prevent the entry of foreign objects into underfloor areas where they may cause jamming of controls. Control

systems should, in general, be routed around cargo compartments. If routing of the control system components is in or near cargo areas, the control system components should be protected by bulkheads, panels, or other enclosures which have sufficient strength and stiffness to prevent possible interference with the control system components when subjected to cargo loading and handling deflections.

(3) Control system details should be reviewed for possible moisture collection. Areas should drain free. Exposed or open control areas should drain free and areas of possible freezing moisture collection should not accumulate ice that would cause a jam of the controls. Simulated or actual ice collection on the controls may be used to prove questionable features. The areas to be considered for moisture collection include both external and internal areas where moisture may accumulate by direct impingement of water, entrapment of water particles, or condensation of moisture.

AC 27.685A. § 27.685 (Amendment 27-26) CONTROL SYSTEM DETAILS.

a. Explanation. Amendment 27-26 adds §§ 27.685(d), (e), and (f) for cable systems, control system joints, and bearings, which are compatible with the same pre-existing paragraphs of § 29.685 except cables of 3/32 inch diameter are allowed by this section rather than the minimum of 1/8 inch diameter required by § 29.685 for transport rotorcraft.

b. Procedures. All of the policy material pertaining to this section remains in effect. This material is supplemented with the following:

(1) The latest revisions of MIL-HDBK-5D do not explicitly give approved pulley-cable combinations, but appropriate MIL specifications are referenced in Chapter 8.3 of MIL-HDBK-5D for use in determining pulley-cable combinations and ratings.

(2) Adhere to the ratings, factors, and alignment as specified.

(3) Provide inspection means as specified for the control system.

(4) Close fitting pulley guards are required for cable systems.

AC 27.687. § 27.687 SPRING DEVICES.

a. Explanation.

(1) This standard for control systems ensures that springs and spring devices used to prevent flutter, control oscillations, or vibrations are either --

(i) Reliable (failure is extremely remote); or

(ii) The failure is not critical to the rotorcraft.

(2) Tests simulating service conditions are required in either instance.

b. Procedures.

(1) Springs and spring devices used in the control system, including balance springs, should be identified early in the certification program.

(2) Whenever a spring cannot be proven by observation or analysis that it is “not critical,” then ground or flight tests may be required.

(3) Springs that are critical to safe operation may be subject to fatigue substantiation to prove they are reliable for the operating conditions imposed in service.

(4) Springs used in conjunction with hydraulic actuator spool valves may be subject to the standards of § 27.695.

AC 27.691. § 27.691 AUTOROTATION CONTROL MECHANISM.

a. Explanation.

(1) Rotorcraft designs generally have a main rotor blade collective pitch control system that does not have detents or other devices to limit pitch control in the control midrange. Autogyro and other rotorcraft designs may include detents or other finite position control for collective pitch control. This rule requires that the control design allows rapid entry into autorotation after a power failure.

(2) Section 27.33 contains standards concerning establishment and control of the main rotor speed limits. The standard requires flight tests and demonstrations. The standard also concerns rotorcraft design features that are related to control of the main rotor speed limits.

(3) Other design requirements for control systems are contained in § 27.685.

b. Procedures.

(1) If high and low main rotor pitch stops are employed in the collective control and if the control may be rapidly moved from one limit to the other, compliance is shown.

(2) If detents or intermediate stops are employed, the pilot must be able to easily and readily override, disconnect, remove, or bypass the device to allow rapid autorotational entry prior to exceeding transient low speed rotor limits. An early assessment of the design may be accomplished by the flight test personnel with the evaluation completed in the Type Inspection Authorization (TIA) test program.

(3) It is acknowledged that modern rotorcraft designs may have an autorotational V_{NE} that is lower than “power-on” V_{NE} or normal cruise speed. For rotorcraft designs with this characteristic, the speed must be reduced after entry into autorotation. No relief from the rule is required since many phases of operation occur at speeds less than power-on V_{NE}. For example, a critical phase of flight occurs during takeoff. Rapid entry into autorotation is essential during this phase also.

(4) The features of the autorotational control mechanism and ability to control the rotor speed within the design limits for any rotorcraft will be evaluated as an integral part of the TIA test program.

AC 27.695. § 27.695 POWER BOOST AND POWER-OPERATED CONTROL SYSTEM.

a. Reference Regulations. The following sections of Part 27 are either incorporated in the provisions of § 27.695 or are otherwise applicable to power boost and power-operated control systems:

(1) Section 27.307 Proof of structure.

(2) Section 27.571 Fatigue evaluation of fight structure.

(3) Section 27.671 Control system.

(4) Section 27.681 Limit load static tests.

(5) Section 27.687 Spring devices.

(6) Section 27.685 Control system details.

(7) Section 27.861 Fire protection of structure controls and other parts.

(8) Section 27.863 Flammable fluid fire protection.

(9) Section 27.1301 Function and installation.

(10) Section 27.1309 Equipment, systems, and installations.

b. Explanation.

(1) The rule requires an alternate system if a power boost or power-operated control system is used.

(2) The alternate system must, in the event of any single failure in the power portion of the system, or in the event of failure of all engines:

(i) Be immediately available.

(ii) Allow continued safe flight and landing.

(3) The alternate system may be:

(i) A duplicate power portion of the system; or

(ii) A manually operated mechanical system.

(4) The power portion of the system includes:

(i) The power source (such as hydraulic pumps); and

(ii) Items such as valves, lines, and actuator.

(5) The failure of mechanical parts (such as piston rods and links) must be considered unless their failure is extremely improbable.

(6) The jamming of power cylinders must be considered unless their jamming is considered extremely improbable.

c. Procedures. It is assumed in the following discussion that the power boost or power-operated control system being utilized is a typical aircraft hydraulic system.

(1) The rule requires, without respect to the probability of failure, an alternate system for the power portion of the system. The power portion of the system, by example in the rule, includes hydraulic pumps, valves, lines, and actuators. It has also been interpreted to include seals, servo valves, and fittings.

(2) If a duplicate power portion of the system is used to meet the requirements of the rule, the requirements may be met by providing a dual independent hydraulic system, including the reservoirs, hydraulic pumps, regulators, connecting tubing, hoses, servo valves, servo-valve cylinder, and power actuator housings. There must be no commonality in fluid-carrying components. A break in one system should not result in fluid loss in the remaining system.

(3) Dual actuators should be designed to ensure that any single failure in the duplicated portion of the system, such as a cracked housing, broken interconnecting input, or broken interconnecting output link, does not result in loss of total hydraulic system function.

(4) A manually operated mechanical system may be used as the alternate system to a single hydraulic system if, after the loss of the single hydraulic system, the

pilot can control the rotorcraft without undue mental or physical fatigue in any normal maneuver for a period of time as long as that required to effect a safe landing.

(5) The substantiation of the various system components should include consideration for operation in the normal and alternate system modes.

(6) The “extremely improbable” criteria noted in § 27.695(c) for failure of mechanical parts may be satisfied by performing component fatigue testing and establishing a service life through this technique.

(7) Fatigue substantiation of the control actuator is required under § 27.571 and should consider both the stresses imposed by flight loads and the stresses imposed by hydraulic pump pressure pulses. Flight loads factored in a conservative way may be an acceptable means to take into account both effects.

(8) The possibility of jamming of the power cylinder may be shown as “extremely remote” through a failure analysis that considers every possible system component failure such as, but not limited to, ruptured lines, pump failure, regulator failure, ruptured seals, clogged filters, jammed servo valves, broken interconnecting servo valve inputs, broken interconnecting output links, etc.

(9) Three acceptable means to meet the requirements of § 27.695(a)(2) could be as follows:

(i) Provide two transmission-driven hydraulic pumps, provided the pumps are driven by the transmission during all flight conditions including autorotation.

(ii) Use two electrically-driven hydraulic pumps if electrical power is available to drive the pumps with all engines failed. If this approach is used, the battery must be capable of running both pumps plus all other required equipment necessary for continued safe flight.

(iii) Use a single transmission-driven pump and an electrically driven pump.

SUBPART D - DESIGN AND CONSTRUCTION

LANDING GEAR

AC 27.723. § 27.723 SHOCK ABSORPTION TESTS.

a. Explanation.

(1) Limit and “reserve energy” drop tests are required as prescribed in §§ 27.725 and 27.727, respectively. These tests may be conducted on the complete rotorcraft or on units consisting of wheel, tire, and shock absorber in their proper relation. For rotorcraft with skid landing gear, the tests may be conducted on the complete rotorcraft or on a simulated fuselage with the complete skid landing gear system.

(2) The rotorcraft must be designed to limit load factors that equal or exceed the limit load factor substantiated by these drop tests. In practical application, the rotorcraft may be designed to a limit load factor, such as 2.8g. Thus, it is necessary that the limit landing load factor derived from the landing gear drop tests be equal to or less than 2.8g. If not, the rotorcraft must be redesigned for the higher load factor derived from the drop tests. It must be shown in accordance with § 27.723 that the limit load factors selected for design under § 27.473 will not be exceeded in landings with the limit descent velocity corresponding to the drop height specified in that section. In addition, reserve energy absorption capacity of the landing gear must be shown for a descent velocity of 1.22 times the limit descent velocity selected under § 27.473 by increasing the drop height to 1.5 times the “limit” drop height. The test requirements or procedures outlined in Part 27 for obtaining the landing load factors are empirical; however, these procedures are based on and supported by satisfactory experience.

(3) As stated in § 27.725(c), each landing gear unit should be tested in the attitude simulating the landing condition that is most critical from the standpoint of the energy to be absorbed by it. For wheel landing gear designs, the level landing or tail down landing and level landing with drag are generally the most critical attitude. A test of more than one attitude may be required to comply with the standard.

(4) Drop tests are required. If analytical methods and/or means are proposed by the applicant, the data presented for approval must be equal to or conservative with respect to that data obtained from physical drop tests. Section 21.21(b)(1) concerns “equivalency” determinations. Presenting an acceptable means of “equivalency” here would circumvent the necessary scrutiny of an analytical method or means and is also beyond the scope of this document.

b. Procedures. The test plan or proposal must be approved prior to official FAA/AUTHORITY tests unless satisfactory resolution of outstanding proposal or conformity inspection items can be accomplished after the test.

(1) The following headings would be a typical table of contents for the test proposal, and a generalized explanation of the contents that may be included under each of these headings for a wheel landing gear follows.

(i) Purpose. The regulations to which compliance is being shown by the drop tests should be identified (usually §§ 27.723, 27.725, and 27.727). Also, the rotorcraft landing gear, including the wheels and tires to be dropped, should be positively identified in the report by the manufacturer's or applicant's previously FAA/AUTHORITY-approved drawing, technical standard orders (TSO's), or other identifying FAA/AUTHORITY-approved data as applicable.

(ii) Description of test setup. This section should present a description of the test fuselage or jig, method of attaching landing gear to jig, and type of accelerometer to be used to measure load factors. Proof of calibration of accelerometer should be available. The accelerometer should be mounted at the aircraft CG if a free drop of the aircraft is used or as close as practical to the centerline of the main shock absorbing component of each landing gear (oleo, strut, etc.) if each gear is tested separately. The description of the test jig, including platforms on which the gears are to be dropped, should be defined by sketches in addition to the required mathematical calculations. This data should show that the landing gear will be at the proper attitude, relative to the platform, on impact for the particular landing condition. Drawings or other approved data from which the geometry is taken should be referenced in the proposal. The tire and oleo pressures at the time of the test should be specified. The method of measuring the deflection of the tire plus the vertical travel of the axle under impact should be described. This measurement may be accomplished by telescoping tubes attached to the point on the jig that would measure the total (tire and oleo) vertical deflection of the landing gear. Other vertical and horizontal deflections should be measured as required to determine if the landing gear has experienced permanent deformation after each drop test. The effect of surface roughness should be considered. Smooth surfaces tend to give maximum deflections where rough surfaces tend to restrict deflection and to result in maximum values of N_Z. Preliminary company drop tests (at less than limit drop height) may be used to determine the critical surface roughness, or engineering evaluations may be used (without tests) when the gear configurations are such that the critical surface condition can be analytically determined (or when the load factor is shown to be negligibly affected by surface roughness). NACA Report 1154, dated 1953, contains information that surface coefficients of friction may vary from 0.4 to 0.7. Skid landing gear standards, § 27.501(c), indicate an acceptable coefficient of friction is 0.5. A wheel landing gear design standard, § 27.479(b), indicates an acceptable coefficient of friction is 0.25. In the case of a small rotorcraft, the entire aircraft may be dropped. This may be accomplished by establishing pivot points at the main gear axles for the tail (or a point forward of the nose gear) drops and a pivot point at the tail (or nose gear) axle for the main gear drops. It is the responsibility of the applicant to distribute the aircraft inertia items, including added weight to get the proper effective drop weight (W_e) at the landing gear, so that no local failures of the aircraft occur as a result of the limit or reserve energy drop tests.

(iii) Test data. Computations for the required drop height (h) and the effective drop weight (W_e) should be shown for each design level landing and tail down landing condition in compliance with §§ 27.479 and 27.481. The computations should be in accordance with § 27.725(a) for h and § 27.725(b) for W_e for the limit drop tests. W_e and h are computed in accordance with § 27.725 for the limit drop test and with § 27.727 for reserve energy drop test. The computation of the static weight on the gear being dropped (W_M, W_N, or W_T) and used in the computation of W_e should be shown. This static weight is defined as W_M, W_T, or W_N for the main gears, tail gear, or nose gear, respectively, in § 27.725(d). It should be shown that the critical CG and proposed certificated maximum landing weight have been used in the computation of W_M, W_T, or W_N. The computation of the slope of the platforms required for the inclined reaction conditions should be presented also.

(iv) Test results. The results of the test are based on the values of W_e, h, d, W, and L used and obtained for each drop test and the value of N_j obtained from the accelerometer. These results should be summarized, and the method of computing the aircraft limit inertia load factor should be shown for each drop in accordance with § 27.725(d). A print or copy of the film or other recording trace from the accelerometer, if not a direct readout type of accelerometer, should be included in the test results. Each critical condition should have several preliminary drops, as many times as required, to obtain reasonable correlation.

(2) Skid landing gear may be tested using similar procedures except a level landing attitude drop test is all that is required by § 27.501. The design load conditions specified in § 27.501(c) through (f) are derived from this level drop test condition.

(i) Section 27.501(a)(2) and (3), contain special considerations for skid landing gear.

(ii) Section 27.501(a)(2) specifies that structural yielding of elastic spring members under limit load is acceptable. This yielding or deformation is a means of absorbing the landing impact. For skid landing gear that uses oleo or other types of shock absorbers, the standard does not allow structural yielding under limit load. During the limit load and reserve energy (ultimate for skid landing gear with elastic spring numbers) drops, the yielding energy absorbing members will probably deform or yield. After a limit drop test, the gear may be used for a reserve energy drop at the discretion of the applicant, but a gear that has been subjected to a reserve energy drop should not be used unless it can be shown that no yielding has occurred in that gear.

(3) Wheel landing gear is tested in attitudes prescribed in paragraph AC 27.723a(3). Each unit, nose or main gear, is generally tested separately.

(4) Skid landing gear is tested in attitudes prescribed in paragraph AC 27.723a(3). Due to the construction of skid landing gear, the complete skid landing gear is tested as a unit. Thus, the level landing with drag condition is probably the critical attitude for the forward cross-tube and its attachments. The level landing condition is probably the critical attitude for the aft cross-tube and its attachments.

(5) An FAA/AUTHORITY or FAA/AUTHORITY designated or delegated person need only witness the drop tests for "record" or "compliance." Preliminary or developmental drops do not require an FAA/AUTHORITY witness.

AC 27.725. § 27.725 LIMIT DROP TEST.

a. Explanation. Limit drop tests in the critical aircraft attitude or critical attitude of each gear are required for the landing gear. The drop height must be at least 8 inches, which equates to a 393-foot-per-minute (free fall) vertical descent speed. Rotor lift may be simulated, and an effective mass may be used in the drop test as prescribed.

b. Procedures. See paragraph AC 27.723, § 27.723.

AC 27.727. § 27.727 RESERVE ENERGY ABSORPTION DROP TEST.

a. Explanation.

(1) In addition to the limit drop tests, a reserve energy drop test is required. The landing gear must not collapse in this test to the extent that the fuselage impacts the ground. Fracture (to separation) of landing gear parts is considered collapse of the landing gear. This test is not an ultimate load drop test for the landing gear, except as specified in § 27.501(a)(3) for certain skid landing gear designs using elastic spring members.

(2) All other types of landing gear must be substantiated for design ultimate loads in addition to this reserve energy drop test.

(3) Shock absorbing devices, such as oleos, must not "bottom" during the reserve energy drop test. "Bottoming" occurs when displacement of the device no longer occurs with increasing load.

(4) Requirements for proof of the landing gear and airframe structure are found in §§ 27.305, 27.307, and 27.473.

b. Procedures. See paragraph AC 27.723, § 27.723.

AC 27.727A. <u>§ 27.727 (Amendment 27-26) RESERVE ENERGY ABSORPTION DROP TEST</u>.

a. <u>Explanation</u>. Amendment 27-26 defines the word "collapse" as used in § 27.727(c). Collapse of the landing gear during reserve energy absorption drop tests occurs when:

(1) A member of the landing gear will not support the rotorcraft in the proper attitude; or,

(2) A landing gear member deforms sufficiently to allow the rotorcraft structure other than the landing gear and external accessories to impact the landing surface.

b. <u>Procedures</u>. The procedures of paragraph AC 27.727A continue to apply with the following supplemental guidance.

(1) The proper attitude for the rotorcraft after the reserve energy absorption drop test is an attitude which allows for permanent deformation of landing gear elements but provides for adequate egress from the rotorcraft. Refer to paragraph AC 27.807 for emergency exit standards that relate to attitudes after a crash, § 27.807(b)(2).

(2) External accessories that may not impact the level landing surface during drop testing (or equivalent gear deflections) include devices such as externally mounted fuel tanks or accessories likely to cause post-landing fires. Expendable accessories, such as cameras, loudspeakers, and search lights, may be damaged during landing gear deformations resulting from reserve energy drop tests if electrical connections are sufficiently protected to preclude electrical fires and the devices are not likely to penetrate a fuel compartment or occupied areas. The expendable accessories, if installed, should also be designed to not have "hard points" that would unacceptably damage the rotorcraft structure under landing impacts by penetration into the occupied areas or fuel tanks. Design features may be employed to preclude this penetration if possibly hazardous. The expendable accessories, if installed, should be designed with frangible fittings, frangible devices, or comparable design features. Also, these devices should be designed to not significantly alter the energy absorbing ability or design features of the landing gear.

AC 27.729. <u>§ 27.729 (Amendment 27-21) RETRACTING MECHANISM</u>.

a. <u>Explanation</u>.

(1) This standard was added by Amendment 27-21.

(2) Structural substantiation is required for the gear, retracting mechanism, doors, gear supporting structure for landing loads, maneuvering, gusts, and yawing

flight condition loads. Design maximum airspeed for extension and retraction and for fully extended conditions are required conditions.

(3) An emergency means to extend the gear after failure of the retraction/extension system is required for all except solely manual mechanical systems.

(4) This regulation requires an indication to the pilot when the gear is secured in the extreme positions. This rule does not apply to rotorcraft that have fixed gear but does apply to amphibious rotorcraft with retractable gear.

(5) A “landing gear down” lock is required. An optional uplock may be used if it meets reliability requirements.

(6) A (ground) operation test should be conducted to ensure proper functioning of the system.

(7) Location and operation of the control lever or device must comply with § 27.777. This section includes identification of controls to prevent confusion and inadvertent operation. Amendment 27-21 added new § 27.779 for motion and effect of cockpit controls. Specifically, § 27.779(c) pertains to motion and effect of normal landing gear controls. Section 25.781 of Part 25 contains large airplane design requirements for motion, effect, and shape of cockpit controls and their knobs and should be consulted for further guidance.

(8) A landing gear warning is required as prescribed in § 27.729(g). Certain features are required. The landing gear shall be extended and locked.

b. Procedures.

(1) The design load factors and resulting loads should be derived from the design data. The landing gear, while retracted, operating, and extended, and its supporting structure should be substantiated for the critical aerodynamic and inertia loads. Yawed conditions should be considered. The specific conditions are noted in § 27.729(a)(1), (a)(2), and (a)(3).

(2) Wheel well doors, if installed, should be designed for the aerodynamic loads, including loads from yawing conditions (angles selected by the applicant) for airspeeds up to the design maximum landing gear extended speed. Aerodynamic effects on both open and closed doors must be considered in the door and door support substantiations. The applicant may choose to substantiate the rotorcraft for a “landing gear operating” and “extended” speed V_{LO} and V_{LE}, respectively, that is equal to the rotorcraft V_{NE}. This option will alleviate an airspeed “structural limitation” because of the landing gear design substantiation. Any airspeed “structural limitation” should be listed in the structural limitations part of the TIA.

(3) The required “downlock” should be checked during the operation test. The design drawing should be reviewed for compliance prior to conducting an operation test.

(4) If an optional “uplock” is installed, the landing gear should be extended during the operation test after simulation of the critical failure mode of the retraction system.

(5) An “operation” test plan or proposal submitted for compliance with § 27.729 should include the items noted in 301b(3) and (4) above and should include a functional check of the position indicator system. Those ground tests must be satisfactorily completed before issuing the TIA.

(6) During the official FAA/AUTHORITY flight tests, compliance with the emergency operation, position indicator, and control aspect of § 27.729(c), (e), (f), and (g), respectively, will be verified or accomplished. In addition, the F&R test program plan (§ 21.35) will specify certain tests or evaluations for the retraction system.

(7) Position Indicator Evaluation.

(i) When evaluating the position indicator system, emphasis should be placed on the switches and their installations and on the cockpit presentation. Each gear must have its own set of switches to indicate when it is secured in its extreme “up” position and its extreme “down” position. The switches must be located to give a valid indication of the arrival of the gear at its extreme position.

(ii) The reliability and environmental qualifications of the switches to be used should be carefully considered. An example of a condition that has potential for trouble is operation on wet areas. Trouble starts when water is picked up by the tires and deposited on the switches. During winter months, the water can freeze, and the resulting ice may prevent the switch from functioning properly.

(iii) An acceptable cockpit presentation consists of two lights for each gear. One light is colored “green” and indicates when its gear is secured in the extreme “down” position. The other light is colored “amber” and indicates when its gear is in transit. When the gear is in either extreme position, the in transit light is “out.” For this presentation the indication to the pilot that the gear is in the extreme “up” position is an all-gear lights-out condition.

(8) Warning System.

(i) A warning system to alert the crew if the landing gear has not been fully extended and locked is required.

(ii) The landing gear warning system that is provided should be evaluated by a flight test pilot. A primary concern should be that the warning device provided is distinctive in its operation from other warning devices incorporated into the rotorcraft cockpit design.

(iii) An acceptable method of interlocking a normal landing mode and the position of the landing gear would be through the selection of some appropriate speed that is less than V_{LE}. The system would be instrumented such that if the gear is not down and locked and the rotorcraft goes below the selected airspeed, the landing gear warning device would be activated.

(iv) An acceptable manual shut off capability would be one that allows disabling the warning device and yet will automatically reset itself when the landing gear is cycled or retracted, or the rotorcraft's speed is increased above that speed selected to activate the warning device.

(v) The appropriate provisions of § 27.1309 should be used to evaluate the impact of system malfunctions.

AC 27.731. § 27.731 WHEELS.

a. Explanation. This standard requires use of approved wheels, either approved under TSO-C26 or approved under the type certificate for the aircraft. Wheels must satisfy both a design static (1g) load and design limit landing or taxiing load determined under the applicable ground load requirements. Standards for a tire installed on a wheel are contained in § 27.733.

b. Procedures.

(1) The structural design loads data shall contain both a static load and a landing and taxiing load for each wheel. These loads are determined by virtue of compliance with the standards of § 27.731(b) and (c). The ratings of the wheel shall not be exceeded. TSO-C26c contains minimum performance standards for TSO approval of aircraft wheels and wheel-brake assemblies. Ratings are assigned in accordance with this performance standard.

(2) If a wheel selected for an aircraft design has TSO-C26 approval, the wheel manufacturer will supply the rating to the aircraft manufacturer. Each wheel shall be marked as prescribed which includes a listing of the TSO number. Even though a wheel is TSO approved, the application on the aircraft (loads imposed on the wheel) requires proof that the rating is not exceeded.

(3) If a wheel selected for an aircraft design is not approved under TSO-C26, the necessary data, both detail design and assembly drawings and qualification tests and test report data, will be required to comply with the standards contained in Part 27. Design control and inspections will be accomplished as a part of the aircraft type design. Structural substantiation and any appropriate qualification tests shall be accomplished. See §§ 27.471 through 27.497 for the ground load conditions.

(4) The Tire and Rim Association, Inc., generally issues a yearbook listing tire and rim sizes and ratings. The dimensions and contours for aircraft wheel rims are contained in Section 9 of this yearbook.

AC 27.733. § 27.733 (Amendment 27-11) TIRES.

a. Explanation.

(1) This standard specifies both design and performance criteria for tires. The tire must fit the wheel rim. The maximum static ground reaction for the condition specified must not exceed the maximum static load rating of each tire. In addition, any tire of retractable gear systems must have adequate clearance from surrounding structure and systems as specified.

(2) Main, nose, and tail wheel tires must comply.

(3) Tire performance standards are contained in TSO-C62.

b. Procedures.

(1) The aircraft structural design loads should contain a maximum static load imposed on the tires. The load is derived for a static ground reaction assuming the design (maximum) weight and the critical center of gravity for each tire of the landing gear. The wheel loads are determined under § 27.731(b). Reduced weight but forward CG conditions may result in the highest static load on a nose wheel tire. Thus, combinations of weight and CG locations require investigation for the maximum tire load of each main, nose, and tail wheel tire.

(2) The maximum possible size of the tires considering appropriate temperatures, aging, and pressure should be obtained to check wheel well and cover clearances. Tire dimensions (for clearances) may be found in the yearbook noted in paragraph AC 27.733b(4). If the tire clearance is questionable, objects may be taped to the tire to simulate tire growth or oversize dimensions expected and the wheel retracted and rotated by hand to check for possible interferences. Minimum clearance, such as one-half inch, may be adequate as a design objective. The design drawings should be reviewed for information of correct systems installations and landing gear rigging within the wheel wells and wheel covers, if installed. If necessary to control tire sizes, specific manufacturer's tires should be used as "required equipment" and the tire manufacturer and the part number should be specified in the design data and on the type certificate data sheet as "required equipment."

(3) As specified in paragraph d of § 27.729 adopted by Amendment 27-21, an operation test of any retractable landing gear should be performed. During this operation test, the tire clearances described in paragraph AC 27.733b(2) should be

determined and recorded. Only the least or minimal clearance found, if adequate, should be recorded in the type inspection report or other appropriate type design report.

(4) The Tire and Rim Association, Inc., generally issues a yearbook listing tire and wheel rim sizes and ratings. This information is advisory as stated in the yearbook. Section 9 concerns aircraft tires and rims. Table AP-5 in Section 9 of the yearbook concerns tires used on rotorcraft. The tire may be selected initially from the yearbook, but qualification data for the specific tires used shall be furnished with the type design data in compliance with the standards. Section 9 also contains tire size and tire growth dimensions.

(5) Aircraft Tires. Minimum performance standards for aircraft tires, excluding tail wheel tires are found in TSO-C62, Aircraft Tires. Tires meeting TSO-C62 are marked as prescribed in the standards. The load rating (reference § 27.733) is marked on the tire. TSO tires are not required but should be used whenever possible. The manufacturer's information, such as load rating, should be included in the aircraft type design structural substantiation data.

AC 27.735. § 27.735 (Amendment 27-21) BRAKES.

a. Explanation.

(1) Brakes are required for wheel landing gear aircraft. Minimum performance standards are contained in this section. During the course of the FAA/AUTHORITY flight test program and of any F&R program conducted under § 21.35, the brakes shall be used and evaluated.

(2) Design criteria are contained in this standard.

(i) The braking device must be controllable by the pilot. It is optional for the second pilot station except as may be specified under the provisions of § 27.771.

(ii) The braking device must be usable during power-off landings.

(3) Performance criteria are also contained in this standard.

(i) The brakes must be adequate to counteract any normal unbalanced torque when starting or stopping the rotor or rotors.

(ii) The brakes must be adequate to hold the rotorcraft parked on a 10° slope on dry, smooth pavement.

(4) In §§ 27.493(b)(2) and 27.497(g)(2)(ii), limiting brake torque is one ground load standard for design of the landing gear.

(5) Although not specifically noted in a standard, the position of the brake on the wheel is important. The brake should be positioned to avoid ground contact whenever the tire is deflated.

(6) TSO-C26 contains minimum performance standards for aircraft landing wheels and wheel-brake assemblies. For rotorcraft, a wheel-brake assembly design rating is established by the manufacturer. The TSO standard for rotorcraft brakes specifies a 20° slope standard (rather than a 10° slope) for an over-pressure hydraulic brake test.

(7) The brake application device at the pilot station is subject to other structure strength standards in this Part, such as the limit pilot forces or torque specified in § 27.397.

b. Procedures.

(1) Wheel-brake assemblies approved under TSO-C26 will have various (rotorcraft) ratings as specified in the standard. One rating of TSO standard for a rotorcraft wheel-brake assembly is the kinetic energy capacity in foot-pounds at the design landing rate of absorption. The design takeoff and landing weight and rotorcraft speed in knots for brake application are a part of the equation. The brake manufacturer should furnish this rating and the two noted parameters for the selected design or designs. The ratings of selected brakes should be included in a structural design data report such as a design criteria report. The use or application of each brake design on the particular rotorcraft design should not exceed capacity of the brake or the ratings established under TSO-C26. If appropriate, the part number and manufacturer of each brake may be listed in the structural data reports as well as listed in the type design drawings.

(2) The limiting brake torque obtained from the brake manufacturer should be used in complying with § 27.493(b)(2).

(3) Compliance with the brake standards should be confirmed, demonstrated, and recorded as a part of the flight test type inspection report. This applies to TSO-C26 brakes and to brakes approved as a part of the aircraft type design.

(4) If found necessary under the provisions of § 27.771, the second pilot station should have brake control devices. The brake control devices should be listed with the other required equipment that defines the equipment necessary for a second pilot station.

(5) A brake assembly may be evaluated and approved under Part 27 as a part of the aircraft type design. TSO-approved brakes are not specifically required but are recommended. For non-TSO-approved brakes, all detail and assembly drawings, required test proposals, and test results reports may be submitted and processed as a unique part of the particular aircraft type design.

(6) During an inspection of the landing gear, such as an engineering compliance inspection, the brake location should be checked to ensure the brake does not contact the ground when the tire is deflated. Type design drawings should control the proper location of the brake on the landing gear.

AC 27.737. § 27.737 SKIS.

a. Explanation. This standard is derived from airplane standards. Aircraft skis approved under TSO-C28 may be used on rotorcraft. TSO-C28 for aircraft skis refers to Sections 4 and 5 of National Aircraft Standards Specification 808, dated December 15, 1951, for strength and performance standards. These standards are conservative for rotorcraft ski installations.

(1) A maximum limit load rating is assigned to each ski approved under TSO-C28.

(2) This limit load rating must not be exceeded by the maximum limit ground load determined under the standards of § 27.505, Ski landing conditions.

(3) Ski mounting or installation parts used in the particular application are subject to substantiation as any landing gear member is subject to substantiation.

(4) Ski installations are also subject to flight and ground operation evaluations.

b. Procedures.

(1) The limit load rating for the ski selected shall be obtained from the ski manufacturer. This information shall be included in the design criteria and/or structural substantiation reports. The type design drawings will include the appropriate part number for the TSO-approved product and the necessary installation information.

(2) The design limit loads derived in compliance with § 27.505 shall not exceed the ski limit load rating.

(3) Skis that are not TSO approved may be approved as a part of the aircraft type design by complying with the strength and performance standards contained in TSO-C28 (NAS 808).

(4) Pads or “bear paws” installed on skid or wheel landing gear to facilitate operations in snow conditions may be approved as a part of or as an alteration to the aircraft type design. Rational design loads applicable to the particular pad design must be developed and strength substantiating data submitted proving compliance with the strength and performance standards contained in Part 27. In addition, skid landing gear may be subject to excessive vibratory loads while in flight whenever the weight and mass distribution is altered by adding “bear paws.” The effect of additional weight

should be investigated. Resonant vibratory conditions should be avoided or highly damped.

SUBPART D - DESIGN AND CONSTRUCTION

FLOATS AND HULLS.

AC 27.751 § 27.751 (Amendment 27-2) MAIN FLOAT BUOYANCY.

a. Explanation.

(1) The section specifies standards for single and multiple float buoyancy in fresh water. The standard does not apply to ditching/emergency flotation devices, but to amphibian rotorcraft devices.

(2) It is a design and a performance standard. Rigid or inflatable floats may be used. Enough water tight compartments (per Amendment 27-2) rather than a specific number are required to minimize the probability of capsizing when one compartment is flooded or deflated.

b. Procedures.

(1) Excess buoyancy. A minimum of 50 or 60 percent in excess of the maximum certificated weight of the rotorcraft is required for single or multiple floats respectively. The weight of fresh water (density 62.42 pounds per cu. ft.) displaced by fully submerged float or floats (total volume at operating pressure of each float is used) should be a minimum of 50 or 60 percent greater than the maximum certificated weight of the rotorcraft.

(2) Capsizing.

(i) Each float should have enough sealed, separate and approximately equal volume compartments to minimize the probability of capsizing when the critical compartment is flooded or deflated. Five or more compartments in each float are usually necessary to meet the standard. Ten compartments per float have been employed in certain designs.

(ii) An analysis or test or combination thereof may be used, if necessary, to prove a positive margin of stability with the most “critical” compartment in one float flooded or deflated, that is ineffective.

(iii) The location of the floats, and the most critical compartment, the rotorcraft weight, mass moment of inertia, and center of gravity location are also important considerations for capsize stability.

AC 27.753 § 27.753 MAIN FLOAT DESIGN.

a. Explanation. Loads and load distributions are specified for float design as follows:

(1) Bag floats are to be designed for:

(i) The maximum pressure differential developed at the maximum design altitude.

(ii) The vertical loads prescribed in § 27.521(a) distributed over three-fourths of the bag's projected area.

(2) Rigid floats are to be designed for vertical, horizontal, and side loads prescribed in § 27.521 distributed along the length of the float.

b. Procedures. Structural substantiation may be accomplished by static tests or analyses using the specified loads. Substantiation should cover the float and float attachments.

AC 27.755 § 27.755 HULLS.

a. Explanation.

(1) The section requires amphibious rotorcraft with a single hull (main float design) and with auxiliary floats (outriggers) to provide a margin of positive stability great enough to minimize the probability of capsizing when any single (usually the most critical) compartment is flooded. Landing gear wheel tires may be used for stability purposes as well.

(2) Limitations for water operation are not intended by this section, but information for water operation must be included in the rotorcraft flight manual.

(3) Wave height or sea state and buoyancy relative to fresh water is not specified but is encompassed in the objective statement of § 27.751(b).

(4) Section 27.751 specifies an excess buoyancy requirement of 50 percent for single main floats (hulls) and contains a capsize/stability standard also. This section complements § 27.755 for certain hull designs.

(5) Sections 23.751, 23.755, and 23.757 concern design standards for small airplanes and may provide insight into possible rotorcraft hull designs.

b. Procedures.

(1) The main hull must have multiple compartments. Assuming the hull has 50 percent excess buoyancy capacity, six to ten sealed compartments of approximately equal volume would allow loss of one with at least 25 percent excess capacity remaining. However, the attitude of the rotorcraft is critical with respect to capsize stability, and additional compartments may be necessary.

(2) The designer must consider separately the loss of buoyancy for each critical compartment, the aircraft center of gravity, and attitude in the water for the appropriate sea state or water height. Sea state 4, moderate, as noted in figure AC 27.801-1, is acceptable.

(3) The auxiliary floats (outrigger) must have multiple compartments. In addition, wheel tires may be used as a compartment if applicable to the design.

(4) For each critical condition under consideration, a single compartment for either the main hull or auxiliary float should be flooded or collapsed. Combined failures, one in each, are not required.

(5) Model stability (or capsize) tests are encouraged to demonstrate compliance with this section.

SUBPART D - DESIGN AND CONSTRUCTION

PERSONNEL AND CARGO ACCOMMODATIONS

AC 27.771. § 27.771 PILOT COMPARTMENT.

a. Explanation.

(1) Volumes have been written on human factors and their contribution to pilot workload and fatigue. This document cannot begin to address the myriad of considerations involved in pilot compartment design. The intent of the rule is simply to ensure that reasonable human factor engineering practices have been followed. Equipment should be logically grouped within the pilot's reach and view and be easy to operate. Seats should provide a reasonable level of comfort for the normal anthropometric range of pilots for a typical mission duration. Environmental considerations such as radiation from the sun through overhead windows should be addressed. Heating, cooling, and ventilation systems should be adequate for the expected range of operating conditions.

(2) Each pilot compartment and its equipment should allow the minimum flightcrew to perform their duties without unreasonable concentration or fatigue. If there is a provision/requirement for a second pilot, his station should be equipped with primary flight controls. Duplicate wheel brakes are recommended. Duplication of miscellaneous controls such as idle detent switches, RPM beep functions, nosewheel locks, and parking brakes has not been required. The need for duplicate instruments for the second pilot tends to be a function of cockpit size and panel configuration.

(3) Webster defines appurtenances as "accessory objects or apparatus." Items such as blowers, fans, and gyros should not have noise or vibration characteristics which could contribute to pilot fatigue or distraction. Instrument panel vibration is specifically addressed in § 27.1321.

b. Procedures. Initial evaluation of the pilot compartment should be conducted on the ground. However, the cockpit assessment should be an ongoing effort throughout the flight test program. If a second pilot position is provided/required, the adequacy of controls and instruments should be evaluated under all normally expected operating conditions. If a second pilot position is not provided/required, any passenger position in the pilot compartment should be evaluated to ensure that a passenger, properly briefed by the flightcrew, can sit comfortably without inadvertent interference with normal control operations. All equipment should be operated during at least one flight of typical mission profile and duration.

AC 27.773. § 27.773 PILOT COMPARTMENT VIEW.

a. Explanation. The section outlines requirements for pilot view in fairly general terms. Requirements are purposely less stringent than for transport category rotorcraft to allow for cockpit designs ranging from fully enclosed to open to the elements.

b. Procedures.

(1) The following procedures are one acceptable means of evaluating pilot compartment field of view considering only those objects in the pilot compartment and the windshield and its support structure in nonprecipitating conditions. The applicant's design is not required to meet these guidelines, and each design should be evaluated on its own merit. The area of visibility established in the following paragraphs will provide an acceptable level of visibility for a minimum crew of one pilot. In the event that a minimum crew of two, a pilot and copilot, is required, the second pilot should have an area of visibility equivalent to that provided for the pilot but on the opposite side. In this event, the pilot's area of visibility to the left as shown in figure AC 27.773-1 needs only to comply to 60° left, and the copilot's area of visibility to the right needs only to comply to 60° right.

(i) A single point established in accordance with the provisions of this paragraph constitutes the referenced eye position (i.e., a point midway between the two eyes) from which the central axis may be located. The referenced eye position is a reference datum point from which the aircrew station geometry is constructed. The referenced eye position should be located by means of ship's coordinates that contain station reference number, water line, and butt line for both pilot and copilot, if applicable, and comply with:

(A) The pilot's seat in a normal operating position from which all controls can be utilized to their full travel by an average subject, and which should provide for vertical adjustment of the seat of not less than 2.5 inches above and 2.5 inches below this initial vertical position.

(B) The seat back in its most upright position.

(C) The seat cushion depression being that caused by a subject weighing 170 to 200 pounds.

(D) The longitudinal axis of the rotorcraft to be that of "cruise attitude" ($0.9V_H$ or $0.9V_{NE}$ whichever is lower).

(E) The point established not beyond 1 inch to the right or left of the longitudinal centerline of the pilot's seat.

(F) All measurements made from the single point established in accordance with this paragraph.

(ii) A dual lens camera, as photo recorder, should be used in measuring the angles specified in the paragraphs listed below. Other methods, including the use of a goniometer, are acceptable if they produce equivalent areas to those obtained with a dual lens camera. When not using a dual lens camera, compensation should be made for one half of the distance which exists between the eyes, or 1 ¼ inches. With the referenced eye position located as indicated in paragraph AC 27.773b(1)(i), and utilizing binocular vision and azimuthal movement of the head and eyes about a radius, the center of which is 3 and 5/16 inches behind the referenced position (this point to be known as the central axis), the pilot should have the following minimum areas of vision measured from the appropriate eye position. (See figure AC 27.773-1.)

(A) 20° forward and above the horizon between 0° and 100° left.

(B) 20° forward and below the horizon between 10° and 100° left.

(C) 20° forward and below the horizon at 10° left increasing to a point 30° forward and below the horizon at 10° right.

(D) 50° forward and below the horizon between 10° right and 135° right.

(E) 20° forward and above the horizon at 0° increasing to a point 40° above the horizon at 80° right and 100° right and then decreasing to a point 20° forward and above the horizon at 135° right.

(iii) Any vertical obstruction which falls within the minimum area of visibility outlined in paragraph AC 27.773b(1)(ii) should be governed by the following:

(A) Between 20° right and 20° left--no vertical obstruction.

(B) Between 20° right and 135° right -- no vertical obstruction greater than 2.5 inches in width.

(C) Between 20° left and 100° left -- no vertical obstruction greater than 2.5 inches in width.

(iv) Any horizontal obstruction which falls within the minimum area of visibility outlined in paragraph AC 27.773b(1)(ii) should be governed by the following:

(A) The area 15° forward and above the horizon between 135° right and 40° left decreasing to a point 10° above the horizon at 100° left, and 15° forward and below the horizon between 135° right and 100° left should be free from horizontal obstructions.

(B) The area above and below the horizon which is between the minimum area of vision specified in paragraphs AC 27.773b(1)(ii) and AC 27.773b(1)(iv)(A) is limited to one horizontal obstruction above and one below the horizon. These horizontal obstructions should not be greater than 4 inches in width. An overhead window which will provide twice as much additional visibility as that lost due to the obstruction should be located immediately above any obstruction above the horizon. This requirement is in addition to any area of visibility specified by paragraph AC 27.773(b)(2)(ii) which may be included in the overhead window area.

(C) If the instrument panel obstructs any required area between 10° left and 10° right below 20° forward and below the horizon, a window which affords triple equivalent additional visibility should be located immediately below and between the angles of 20° left and 20° right above 65° below the horizon.

(v) For steep rejected takeoffs and steep approaches (such as to oil rigs or confined heliports), the visibility should be such that the pilot can see the touchdown pad and sufficient additional area to the side and forward to provide both an accurate approach to the touchdown point as well as a satisfactory degree of depth perception. A 5-inch head movement by the pilot forward and/or sideward of the normal position is acceptable in determining compliance.

(2) Since glare and reflection often differ with the sun's inclination, consideration should be given to evaluating the cockpit at midday and in early morning or late afternoon. Windshields with embedded wire heating elements should be evaluated for distortion with the system both "ON" and "OFF." If night approval is requested, all lighting, both internal and external, should be evaluated in likely combinations and under expected flight conditions. Although a certain amount of equipment reflection (avionics control heads, etc.) in the windshield may be unavoidable, the pilot's normal field of view should be unobstructed. Windshield reflections often dictate large glareshields resulting in reduction of the optimum field of view. This problem is most apparent in IFR equipped aircraft (having larger instrument panels and avionic consoles) operating in VFR utility roles. Landing and taxi lights should be exercised throughout their adjustment range (if applicable) to check for reflections, particularly in chin windows. Anticollision and strobe lights should be evaluated to ensure that frequency interaction and reflections off the rotor do not result in distractions to the pilot. The effect of cabin lighting on the pilot compartment view should be assessed, particularly on EMS-configured aircraft where the in-flight use of cabin lights may be mandatory.

(3) Moderate rainfall is defined by the National Weather Service as an accumulation of between 0.01 and 0.03 inches in 3 minutes. Since the rule effectively permits open cockpits, a determination of what would unduly impair the pilots' view in moderate rainfall is obviously very subjective. If it is established that rain removal systems are necessary, those systems may be evaluated on the ground with a hose, but they should also be assessed in flight under applicable conditions. Obscuration of side windows by rainfall should be addressed, particularly for confined area approaches. The need for windshield wash systems should be assessed if the aircraft will be used in an offshore salt-spray environment.

(4) If icing certification is requested, a means must be provided to ensure that a sufficiently large viewing area is kept clear of ice to permit safe operation. As a minimum, a clear area on the windshield should be available, although some configurations could require a clear view in other areas to provide an adequate level of safety in certain operations. Systems provided to ensure a clear view in icing conditions should be evaluated during icing flight tests.

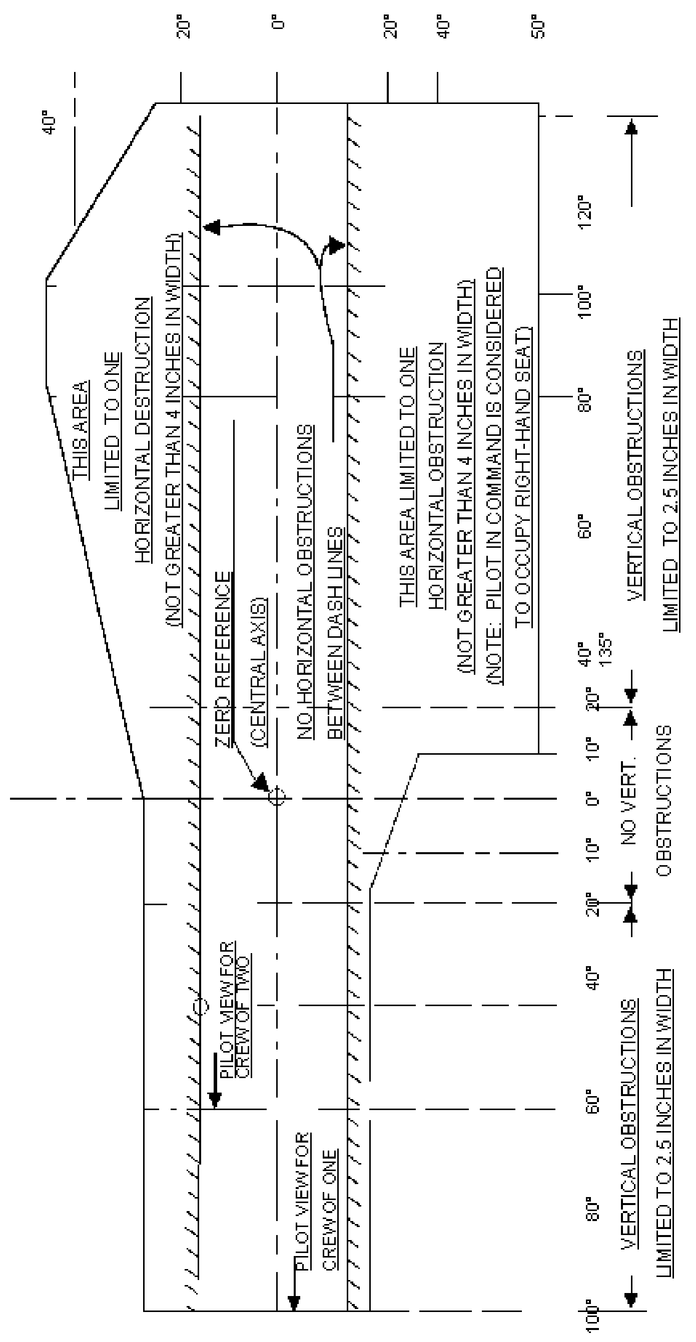

FIGURE AC 27.773-1 COCKPIT VISIBILITY

AC 27.775 § 27.775 WINDSHIELDS AND WINDOWS.

a. Explanation. The use of nonsplintering safety glass is specified when glass is used in windshields and windows to protect crew and passengers in the event that window fracturing occurs.

b. Procedures. Use nonsplintering safety glass in windshield or window applications which contain glass rather than plastic acrylics, polycarbonates, epoxies, etc. The glass selected should meet a specification such as MIL-G-25871, and if new vendors are selected by an airframe manufacturer, test data should be obtained from the vendor to demonstrate the safety glass provided meets an acceptable specification and provides adequate nonsplintering capability.

AC 27.775A § 27.775 (Amendment 27-27) WINDSHIELDS AND WINDOWS.

a. Explanation. Amendment 27-27 changed § 27.775 to allow the use of materials other than nonsplintering safety glass; i.e., plastics are allowed. Additionally, whatever material is used should not break into dangerous fragments upon impact.

b. Procedures. The procedures contained in paragraph AC 27.775 apply equally to glass or plastics.

AC 27.777 § 27.777 COCKPIT CONTROLS.

a. Explanation. This section defines the general cockpit control requirements. Cockpit control location and arrangement with respect to the pilot's seat must be designed to accommodate pilots from 5'2" to 6'0" in height.

b. Procedures.

(1) The applicant should have a cockpit design report which documents the anthropometric suitability of the cockpit. Subsequent cockpit evaluations of control movement and location should be conducted with adjustable seats and/or controls positioned in a flight position for the subject pilot. Essential controls should be evaluated with the shoulder harness locked in the retracted position. Evaluation pilots should be aware of their individual anthropometric measurements and temper their assessments based on this information. Ideally, a new design should include evaluations by a range of different sized subject pilots. Control considerations for a second pilot position are the same as for the pilot station. Paragraph AC 27.771 discusses current philosophy concerning duplication of controls.

(2) As background, the following are examples of cockpit control issues which should be avoided:

(i) Collective control blocking the lateral movement of a pilot's leg, which in turn restricts the left lateral cyclic displacement.

(ii) Seat or seat cushion impeding the aft cyclic movement.

(iii) Inadequate space for large feet equipped with large flight boots.

(iv) Control/seat relationship which requires unusual pilot contortions at extreme control displacements.

(v) Control/seat relationship or control system geometry which will not permit adequate mechanical advantage with unboosted controls or in a boost OFF situation.

(vi) Addition of control panels or equipment to instrument panels or consoles which restrict full control throw.

(vii) Brake pedal geometry which results in inadvertent brake application upon displacement of the directional controls.

(viii) Controls for accessories or equipment which require a two-handed operation.

(ix) Emergency external cargo release controls which cannot be activated without releasing the primary flight controls.

(x) Essential controls which cannot be actuated during emergency conditions with the shoulder harness locked.

(xi) Throttle controls which can be inadvertently moved through idle to the cutoff position.

(xii) Switches, buttons, or other controls which can be inadvertently activated during routine cockpit activity including cockpit entry.

(xiii) Failure to account for operation with the pilot wearing bulky winter clothing.

(xiv) Aft cyclic movement limited by the pilot's body with a fore and aft adjustable seat in the full forward position.

AC 27.779. § 27.779 (Amendment 27-21) MOTION AND EFFECT OF COCKPIT CONTROLS.

a. Explanation. The section standardizes motion and effect of cockpit controls. While this paragraph specifically addresses primary flight controls, engine power controls, and landing gear controls, it applies to all cockpit controls not addressed in other paragraphs.

b. Procedures.

(1) The cyclic should be mechanized such that movement of the control results in a corresponding sense of aircraft motion in the same axis. While a certain amount of coupling may be present following a pure control input in a given axis, that coupling should not be objectionable to the pilot. Collective pitch control should be mechanized such that an upward movement of the collective results in a corresponding relative motion of the aircraft in the vertical plane. Again, coupling should not be objectionable. Care should be taken to insure that the primary pilot's perception of collective motion is in the vertical plane. The objective is to clearly differentiate collective motion from that associated with an airplane throttle. The rule is self-explanatory on the subject of engine power controls. A distinction is made between normal landing gear controls and emergency controls. Emergency controls may operate in a sense which might not correspond to the direction of resultant gear motion.

(2) The recommended operating convention and "switchology" for miscellaneous controls are:

(i) Up/forward = on/increase

(ii) Down/aft = off/decrease

(iii) Variable rotary controls should move clockwise from the OFF position, through an increasing range, to the full ON position. For some variable intensity controls such as instrument lighting, the desired minimum setting may not be completely off. Pushbuttons not giving an obvious indication of mechanical position should be configured such that the flightcrew has a clear indication of switch actuation under both day and night (if applicable) conditions. Failure of the indication should be shown to be free of hazards.

(3) Slew or "beep" switches associated with flight control system applications warrant special attention. The recommended conventions for control-mounted single, or multifunction, two or four-way "beep" switches are:

(i) Cyclic.

Switch Direction	Flight Control System /Autopilot Configuration	Aircraft Response
Forward/up	basic trim	nose down
	airspeed/groundspeed mode selected	increased airspeed forward speed reference
	vertical speed mode selected (without airspeed mode engaged)	increased rate of descent/decreased rate of climb
	hover mode selected	increased ground-speed or forward acceleration reference
Left	basic trim	left wing down
	heading mode selected	slow heading reference left
	hover mode selected	increased ground-speed or acceleration reference to left

(ii) Collective (assumes switch is mounted on top of grip).

Switch Direction	Flight Control System /Autopilot Configuration	Aircraft Response
Forward	control position hold	down collective
	vertical speed mode selected	increased rate of descent/decreased rate of climb
	hover mode selected	decreased hover height reference
Left	control position hold	increase left pedal
	hover mode selected	slow heading reference left

(iii) Opinions are divided concerning the preferred convention for forward and rearward motion of slew switches mounted atop the collective grip. Part of the reason appears to stem from the fact that such a switch is never used in a purely control position trim capacity. The switch has normally remained nonfunctional until a vertical autopilot mode is selected. At that point, the switch is viewed by one pilot/engineer contingent as either an autopilot reference slew function or a power increase/decrease switch which should follow the “forward equals increase” convention. The other group views the switch as a form of control position trim and finds the “forward equals down collective” convention to be more consistent with the sensing used for the cyclic beep switches. An obvious solution is to mount collective/vertical axis switches in a vertical orientation on the grip. Barring that alternative, viable arguments can be made for either philosophy. The recommended convention was selected following a survey of manufacturers and test pilots.

AC 27.783. § 27.783 DOORS.

a. Explanation.

(1) Closed cabins must have at least one external door that is adequate and easily accessible for all of the occupants. The standard envisaged a door intended for normal use and for an emergency exit for all passengers. The passenger compartment, itself, should not be partitioned.

(2) Passenger doors should not be located near main or tail rotors such that persons using the door or doors would be endangered while entering or leaving the aircraft. The discs of engines or other propulsion system devices were not included in this standard. Procedures or instructions may be used to support compliance. Section 27.1565 concerns tail rotor markings.

(3) Cabin doors of normal category rotorcraft should inherently comply with the exit standards in § 27.807(b) concerning the size of the unobstructed opening, accessibility, location, method of opening, arrangement, probable jamming due to fuselage deformation, and possibly markings inside and outside. The standards for the features and characteristics of exits should be applied to cabin doors unless an “exit” is also installed in the same side of the fuselage. The marking standards of § 27.1557(d) for exits should be applied to doors unless the door is readily identified and its opening features are simple and obvious. It is not necessary to use red and white colors, provided the door instructions and markings are conspicuous.

(4) If the door is used as a “ditching exit,” the threshold of the door/exit must be above the waterline of the rotorcraft while in calm water (§ 27.807(d)). Note that “ditching approval” under § 27.801 is an optional standard.

(5) If a lock is used as an optional feature, the lock must not engage inadvertently or, as a result of mechanical failure, prevent possible opening of the door from inside or outside the cabin.

b. Procedures.

(1) The layout of the most dense or critical (from evacuation aspect) interior arrangement should be reviewed as soon as possible in the certification program. Each passenger shall have easy access to each passenger door/exit. The crewmembers may have separate emergency exits or doors on each side of the aircraft separate from the passenger door if desired by the applicant. A mockup may be used to make an early assessment of the interior critical areas for door accessibility, operation of the door, door markings, and other features critical to compliance. A comprehensive interior compliance inspection may be accomplished later in the program to confirm or correct conclusions derived from a review of layout or mockup data.

(2) Mockup interiors used in the preliminary evaluation may not have all padding, liners, compartments; i.e., it may not be a fully equipped interior arrangement.

(3) The door should have clearance with the fuselage door frame to allow reasonable deflection without jamming, or the door may be designed to minimize jamming. So called “rip hinges” may be employed as well. Rip hinges may also serve as the primary emergency release for the door.

(4) If a door has an emergency release system for the door that is separate from a “normal open and close” system, certain standards of § 27.807(b) and (c) should apply.

(5) As good practice, internal and external markings are recommended for each door as follows:

(i) Indicate when the door is closed and fully locked.

(ii) Indicate the means of opening.

(iii) Contrasting colors should be used in markings. Red and white are acceptable but not required. For exit markings, see § 27.1557(d).

(6) Crew and passengers should be protected from the main and tail rotors (discs) as prescribed in § 27.807(b). Two avenues of compliance are noted here.

(i) A layout of the aircraft may be used to evaluate compliance with § 27.783(b). The main rotor should have sufficient clearance to allow a typical person to stand upright, outside, near the door or doors. The auxiliary rotor should be located as far as practicable from any passenger doors. Appropriate instructions for entering or leaving the rotorcraft may be furnished in the flight manual, placards, or equivalent to further reduce possible hazards. Tail rotor marking standards are referenced in paragraph AC 27.1565.

(ii) If necessary, a door and engine or rotor system interlock system may be employed to prevent opening of the door with the rotors operating. Other systems may be used. In case of emergency, the system must allow opening of the door (exit) from inside or outside the rotorcraft.

AC 27.783A. § 27.783 (Amendment 27-26) DOORS.

a. Explanation.

(1) Each closed cabin should have at least one door. A door on the opposite side of the cabin may be used to also comply with the exit requirement of § 27.807.

(2) Amendment 27-26 extends the requirements of § 27.783 to:

- include each external door, not just passenger doors; and,

- require provisions of door location and procedures to protect persons from danger from propellers, engine intakes, and engine exhausts.

b. Procedures. All of the policy material pertaining to this section remains in effect. In addition:

(1) Occupants of the rotorcraft and servicing personnel should be protected from possible injury when using any external door to enter or egress the rotorcraft and when loading cargo or servicing the rotorcraft. Consideration should be given to door location and operating procedures to include protection from propellers (if equipped) and engine inlets and exhausts, as well as from rotors.

(2) These new requirements clarify that engine exhausts, engine inlets, and propellers, as well as rotors, are potentially hazardous and should be located or designed to protect rotorcraft occupants and ground personnel.

(3) Door operating procedures, including readily visible markings, should be provided to minimize possible injury to personnel when practical component locations or component design features, alone, do not assure freedom from possible injury.

AC 27.785. § 27.785 (Amendment 27-21) SEATS, BERTHS, SAFETY BELTS, AND HARNESSES.

a. Explanation.

(1) The standard concerns occupant seat and berth (litter) devices and restraint of the occupant (170-pound weight) for specified conditions. The occupants shall be restrained and protected for flight, landing, and the emergency landing conditions specified in § 27.561(b). This standard and § 27.561 have the objective of providing

each occupant with every reasonable chance of escaping serious injury for the stated conditions.

(2) The standard includes both serious (general) injury, paragraphs (a) and (e), and head injury, paragraph (b). Furthermore, paragraph (b) requires certain design features or practices for head injury protection.

(3) The pilot seats shall additionally withstand the pilot control effort forces stated in § 27.397.

(4) Seat or berth static test or structural analysis conditions (which are procedures) were previously stated but removed by Amendment 27-21.

b. Background.

(1) FAR Part 27 through Amendment 27-20 and its predecessor, CAR Part 6, specified design conditions (flight, landing, and emergency landing conditions, § 27.561) for each seat and berth. Pilot seats were also subject to pilot control forces (reaction) of § 27.397. Structural strength analysis and testing could be simplified or conditions combined as stated. A factor applied to each design load shall be at least the “fitting” factor specified in § 27.625 and applied as stated therein.

(2) Amendment 27-21, adopted November 1984, expanded the standard significantly to contain objective and specific standards for improved occupant protection for flight, landing, and the emergency landing conditions of § 27.561.

(i) A shoulder harness is required for each front seat occupant. A shoulder harness (also called upper torso restraint) or other means shall be used to protect other occupants from head injury. Design features of the belt and harness are also included. A factor of 1.33 was also adopted. Protection while seated or moving about during normal flight and moderately rough air is also a part of the amended standard. This is similar to the transport rotorcraft standards.

(ii) A load distribution between the belt (60 percent) and harness (60 percent) is stated. Design standards for any head rest, if installed, are stated. A factor of 1.33 shall be applied to the design loads for the attachment of each seat to the structure and each belt and/or harness to the seat or structure and the head rest. This factor is applied whether the seat and restraint system is proven by static test or by analysis.

(3) An AC applicable to safety belts and shoulder harnesses for small airplanes has been issued. The information in AC 23-4, “Static Strength Substantiation of Attachment Points for Occupant Restraint System Installations June 20, 1986, should be helpful in complying with § 27.785.

(i) Dynamic impact tests may be voluntarily proposed by the applicant. At least two conditions should be used to be representative of impact cases. Report No. DOT/FAA/CT-85/11, Analysis of Rotorcraft Crash Dynamics for Development of Improved Crashworthiness Design Criteria, June 1985, may be obtained for reference from the National Technical Information Service, Springfield, Virginia 22161.

(ii) Advisory Circular 21-22, Injury Criteria for Human Exposure to Impact, June 20, 1985, may be used for part of the acceptance levels or performance criteria in developing a proper dynamic test proposal. The static design conditions contained in the present standards shall be satisfied also.

c. Procedures.

(1) Each seat with its belts and harnesses are to be substantiated for the flight, ground, and emergency landing loads of § 27.561 by structural test or stress analysis. Approval can be gained by Technical Standard Order (TSO) approval or by accomplishing sufficient structural substantiation to gain certification approval of the seat and its belt(s) and harness as part of the type design of the rotorcraft. TSO No. C-39a concerns standards for aircraft seats, including rotorcraft seats. If TSO No. C-39a is used as an approval basis for a specific rotorcraft seat, the seat and harness should be checked to ensure it has been substantiated for the vertical (up and down) and side loads imposed by installation in the aircraft. For example, TSO No. C-39a (and NAS 809) specifies an ultimate down load of 4.0g which is in agreement with the 4.0g emergency landing load factor of § 27.561, but it may be less than the design maneuver load factor (which can be as high as 3.5g limit or 5.25g ultimate).

(i) The 1.33 factor is specified for substantiation of attachments of each seat to the structure and each safety belt or harness to the seat or structure and the head rest, if used, for § 27.561 loads, whether analysis or test is used.

(ii) If static testing of seats, belts, and harnesses is used, the body block of NAS 809 may be used. The corners of the NAS 809 body block may be radiused and padded if it is found that the small radii cause premature, unrealistic crippling of thin wall tubing or other structure used in the static seat.

(iii) The substantiation of the pilot seats is required to include pilot forces of § 27.397 in conjunction with normal flight and ground loads. For example, the pilot foot force (195 pounds ultimate) must be reacted by the seat.

(2) The head rest, if used, shall be substantiated for a head weight of 13 pounds, § 27.561 inertia load factors, and a factor of 1.33 whether by test or analysis.

(3) The following criteria have been found satisfactory for preventing occupant head injuries:

(i) Whenever a harness is used, it should support the shoulders without applying hazardous loads to the side or front of the neck. It should be easily donned and removed. A single point release with the seat belt is required for each pilot's seat and preferred for other seats. If a separate release is provided, it must be simple, compatible with the seat belt release, and near the seat belt release. The harness should be tested in conjunction with the seat belt using a "body block" similar to that of NAS 809, if possible. It shall be tested to 60 percent of the § 27.561 minor crash loads for the entire occupant weight of 170 pounds. TSO-C114, Torso Restraint Systems, dated May 27, 1987, was recently issued.

(ii) During certification TIA testing, the pilot shall ensure that all of the pilot's necessary functions may be performed with the seat in the most adverse adjustable position and the belt and harness fastened. Each belt and harness shall also be secured, when not used, if necessary, to comply with § 27.785(c).

(iii) Elimination of injurious objects within striking distance of the head and other vital parts can be accomplished by removal of objects with sharp edges or rigid surfaces from within striking distance of vital parts of the occupant. Dimensions and weights for typical occupants are available in U.S. Army USAAVLABS Reports 70-22 (August 1969) and 66-39 (June 1966) and NACA Report TN 2991 (August 1953). Because of the range of occupant head striking distance, a combination of "elimination of injurious objects" and "cushioned rests" may be required for some interior configurations. If only a belt or a belt-harness which allows use of only the belt is installed, the minimum arc or strike sphere requirement may be met by establishing a 35-inch minimum radius strike-free zone from the seat back and bottom cushion junction. The cushions may be assumed to be normally compressed.

(iv) An acceptable cushioned rest can be provided by use of a 1-inch thickness of foamed polyvinyl chloride (PVC) or equivalent energy absorbing material. The density of material should be in a 5- to 10-pound per cubic foot density range. PVC foam has the property of <u>absorbing energy</u> efficiently with negligible rebond effects. PVC foam recovers slowly to the original configuration after deformation. If PVC foam is used, however, care must be taken in its application relative to its flammability characteristics (reference § 27.853).

(4) Handholds for the occupants are generally provided by transport aircraft seat backs adjacent to the aisle. If the seat backs fold, the amount of support provided by the seat backs before they fold must be evaluated in a furnished interior or mockup. To provide adequate support, the seat back may use an easily disengaged latch or adequate friction in the hinge mechanism to obtain adequate support. Handholds along the aisle are, of course, not needed for rotorcraft with no aisles or where seat belts must be fastened during flight according to the operating rules.

(5) Projecting objects which could injure occupants in normal flight should be padded. The amount of padding required depends on the location, size, and minimum

radius of the projecting object. In general, this requirement may be met by padding sharp edges with one-half inch of PVC foam or equivalent energy absorbing material (5 to 10 lbs. density). Objects with edge radii in excess of 1 inch may meet the requirements of § 29.785(e) with a lesser amount of energy absorbing padding, if it can be contacted only by persons while “seated or moving about in the rotorcraft in normal flight.”

AC 27.785A. § 27.785 (Amendment 27-25) SEATS, BERTHS, SAFETY BELTS, AND HARNESSES.

a. Explanation.

(1) The title of § 27.785 now includes berths (which would include litters).

(2) Section 27.785(a) has been revised to include reference to the new § 27.562, “Emergency Landing Dynamic Conditions”.

(3) Section 27.785(b) has been revised to include a reference to the new § 27.562(c)(5) head injury criteria and to describe a torso restraint system that is contained in TSO-C114.

(4) Section 27.785(f) has been revised to change the percentage of load distribution of a combined safety belt and harness from 60-60 to 60-40.

(5) A new § 27.785(i) has been added which provides a list of “seating device system” components.

(6) A new § 27.785(j) provides for deformations of the seat energy absorption device system installed to meet the requirements of § 27.562 but requires that the system “remain intact and not interfere with rapid evacuation of the rotorcraft.” Further “structural” performance standards are contained in §§ 27.562(c)(1) and (2). AC 20-137 also contains information.

(7) A new § 27.785(k) provides static strength and restraint requirements for litters and berths. Litters may be oriented laterally as well as longitudinally in the rotorcraft. Dynamic tests of litters are not required. For longitudinally oriented litters, features should be provided to protect the occupant from the increased loads in § 29.561(b) of Amdt. 27-25.

b. Procedures. The procedures of paragraph AC 27.785 still apply to static substantiation of the seats, berths, safety belts, and harness. In addition:

(1) Compliance with § 27.562 (except litters are not included) and § 27.561(b) is required.

(2) Section 27.562 includes a specific pass fail criteria, which includes head injury criteria (reference AC 20-137).

(3) Shoulder harnesses need only be substantiated for 40 percent of total occupant load rather than the former 60 percent adopted by Amendment 27-21.

(4) AC 20-137 provides guidance for evaluating the functioning of a seating energy absorption device system under dynamic test conditions. Stroking is generally associated with the vertical-horizontal impact case and is recognized in the static strength substantiation.

(5) Berths or litters installed within 15° or less of the rotorcraft longitudinal axis (oriented longitudinally) shall use a combination of restraint devices, such as a padded end-board, cloth diaphragm, or equivalent means to withstand and distribute the occupant loads resulting from § 27.561(b) requirements. Other berths or litters may be equipped with straps or safety belts to withstand the forward reaction of § 27.561(b) as well as other loads, including flight loads.

(i) Berths/litters may be substantiated by static load tests, analysis, or a combination thereof and need not be substantiated to the 1.33 fitting factor of seat installations.

(ii) The berth/litter occupant's head, neck, and spine should be protected from (landing) impact forward loads by appropriate design means; e.g.,

- non-longitudinal orientation of the berth/litter; or
- "feet forward" orientation; or
- distribution of an appropriate percentage of forward loads on the shoulders (not solely to the head and spine).

(iii) Recommendations for litter occupant

- If the occupant's head is oriented forward, a shoulder harness should be provided, in conjunction with body and leg straps, that prevents the occupant's head from falling off the litter. A padded end board, diaphragm, etc., may be used, provided head and spinal loads are alleviated or prevented.
- If the occupant's feet are oriented forward, the padded end board may also be used in combination with body and leg straps or other such restraints.

- Multiple or combinations of devices should be used to distribute the occupant loads as well as protect the occupant from possible neck and spine compression.

AC 27.787. § 27.787 (Amendment 27-11) CARGO AND BAGGAGE COMPARTMENTS.

a. Explanation.

(1) This standard concerns the strength or structural integrity of either a cargo or baggage compartment. For purposes of this paragraph, baggage and cargo compartments are synonymous. Other design standards are also included.

(2) Fire protection standards of these compartments are contained in § 27.855, paragraph AC 27.855.

(3) The compartment must contain the maximum (design) weight cargo for maximum landing and flight load factors. The minor crash conditions noted in § 27.561 are not applied to cargo compartments. However, a forward ultimate load factor of 4 is applied to the contents of cargo compartments. This forward load condition is related to occupant protection. Compartments forward of the occupant's compartment may be designed to the appropriate landing load factor (landing with drag and side load).

(4) Features such as straps, nets, ropes, and possibly other means of restraint may be used when necessary to prevent hazardous shifting of cargo as prescribed under flight and landing loads.

(5) Compartment lamps must be protected from possible lamp bulb and cargo contact.

(6) Other than the standards in this section, specific standard design features for cargo compartment doors are not contained in FAR Part 27. The following are recommended design features.

(i) Door latch or lock mechanism should not fail and allow the door to open and should not open as a result of cargo shifting.

(ii) Crewmembers should by visual means such as handle positions and markings determine, when on the ground, that the door is fully locked. A separate signal system may also be used to show a door unlatched condition.

(7) Compartment marking standards such as maximum weight, floor loading, possible tiedown instructions and other appropriate compartment markings or placards are prescribed in § 27.1557(a).

b. Procedures.

(1) The compartment design allowable load, including distributed loading, is determined during the initial design phases of the rotorcraft. For an example, the compartment may have a placarded maximum allowable load of 250 pounds, with an allowable distributed load of 100 pounds per square foot. The compartment maximum load and floor distributed load (allowable pounds per square foot) should be included in a stencil, placard, or equivalent durable marking per § 27.1557(a).

(2) Static tests or analyses may be used for substantiation. Light weight rotorcraft configurations typically should be associated with the most severe flight and landing load factors.

(3) Structural substantiation of the fuselage for flight and landing loads must include the baggage and cargo restraining devices and associated attachment structure. Structural substantiation of the compartment structure must include the 4g ultimate forward load condition of § 27.787(c) in addition to the flight and landing load conditions. These can be handled as separate conditions if the structure is substantiated by analysis. If static tests are conducted, all load conditions must be accounted for. A test plan should be approved and conformity inspections conducted prior to FAA/AUTHORITY witnessing of tests.

(4) Cargo nets or straps installed for compliance with § 27.787(b) must be substantiated for the maximum flight and landing loads. The forward load condition of § 27.787(c) must be proven also. Nets or straps should be adjustable.

(5) Lamp bulbs should be guarded, recessed, or placed in upper inside corners and guarded to prevent contact with cargo and possible bulb breakage or excessive heat.

(6) If the door design recommendations in paragraph AC 27.787a(6) are accepted, these features should be confirmed by design data review and during a compliance inspection. Index or alignment marks with respect to handle (door locked) position are also recommended. If a signal system is used, a switch at the door latch that would signal “door open or unlatched” to the flightcrew is recommended.

AC 27.787A <u>§ 27.787 (Amendment 27-27) CARGO AND BAGGAGE COMPARTMENTS.</u>

a. <u>Explanation</u>. Amendment 27-27 adds two subparagraphs to § 27.787(c) which clarify that cargo and baggage compartments should be designed to protect occupants from injury by the compartment contents during emergency landings. This may be done by <u>location</u> or by <u>retention provisions</u>. The new paragraphs also add a requirement that the compartment contents not cause injury when subjected to the loads of § 27.561.

b. <u>Procedures</u>. The procedures of paragraph AC 27.787 are still applicable. In addition to the forward load, the cargo and baggage compartment should be designed to withstand loads in other directions as specified in § 27.561. Also, the compartment may be shown to provide protection of occupants by location; i.e., cargo and baggage compartments may be shown to be located in a position where loose contents will not endanger occupants in an emergency landing impact. If the compartment is located above or behind the occupied area, § 27.561(c) may apply. If a compartment is in the occupied area, § 27.561(b) applies.

AC 27.801 § 27.801 (Amendment 27-11) DITCHING.

a. Explanation.

(1) Ditching certification is accomplished only if requested by the applicant.

(2) Ditching may be defined as an emergency landing on the water, deliberately executed, with the intent of abandoning the rotorcraft as soon as practical. The rotorcraft is assumed to be intact prior to water entry with all controls and essential systems, except engines, functioning properly.

(3) The regulation requires demonstration of the flotation and trim requirements under “reasonably probable water conditions.” A sea state 4 is representative of reasonably probable water conditions to be encountered. Therefore, demonstration of compliance with the ditching requirements for at least sea state 4 water conditions satisfies the reasonably probable requirement.

(4) A sea state 4 is defined as a moderate sea with significant wave heights of 4 to 8 feet with a height-to-length ratio of:

(i) 1:12.5 for multiengine rotorcraft with Category A engine isolation (reference paragraph AC 27 MG 3).

(ii) 1:10 for all other rotorcraft.

NOTE: The source of the sea state definition is the World Meteorological Organization (WMO) Table. (See figure AC 27.801-1.)

(5) Ditching certification encompasses four primary areas of concern: rotorcraft water entry, rotorcraft flotation and trim, occupant egress, and occupant survival.

(6) The rule requires that after ditching in reasonably probable water conditions, the flotation time and trim of the rotorcraft will allow the occupants to leave the rotorcraft and enter liferafts. This means that the rotorcraft should remain sufficiently upright and in adequate trim to permit safe and orderly evacuation of all personnel.

(7) For a rotorcraft to be certified for ditching, emergency exits must be provided which will meet the requirements of § 27.807(d).

(8) The safety and ditching equipment requirements are addressed in §§ 27.1411, 27.1415, and 27.1561 and specified in the operating rules (Parts 91, 121, 127, and 135). As used in § 27.1415, the term ditching equipment would more properly be described as occupant water survival equipment. Ditching equipment is required for extended overwater operations (more than 50 nautical miles from the nearest shoreline and more than 50 nautical miles from an offshore heliport structure). However, ditching certification should be accomplished with the maximum required quantity of ditching equipment regardless of possible operational use.

(9) Current practices allow wide latitude in the design of cabin interiors and, consequently, the stowage provisions for safety and ditching equipment. Rotorcraft manufacturers may deliver aircraft with unfinished (green) interiors that are to be completed by the purchaser or modifier. These various "configurations" present problems for certifying the rotorcraft for ditching.

(i) In the past, "segmented" certification has been permitted to accommodate this practice. That is, the rotorcraft manufacturer shows compliance with the flotation time, trim, and emergency exit requirements while the purchaser or modifier shows compliance with the equipment provisions and egress requirements with the completed interior. This procedure requires close cooperation and coordination between the manufacturer, purchaser or modifier, and the FAA/AUTHORITY.

(ii) The rotorcraft manufacturer may elect to establish a "token" interior for ditching certification. This interior may subsequently be modified by a supplemental type certificate or a field approval. Compliance with the ditching requirements should be reviewed after any interior configuration changes and limitations changed where applicable.

(iii) The Rotorcraft Flight Manual and supplements deserve special attention if a "segmented" certification procedure is pursued.

b. Procedures. The following guidance criteria has been derived from past certification policy and experience. Demonstration of compliance to other criteria may produce acceptable results if adequately justified by rational analysis. Model tests of the appropriate ditching configuration may be conducted to demonstrate satisfactory water entry and flotation and trim characteristics where satisfactory correlation between model testing and flight testing has been established. Model tests and other data from rotorcraft of similar configurations may be used to satisfy the ditching requirements where appropriate.

(1) Water entry.

(i) Tests should be conducted to establish procedures and techniques to be used for water entry. These tests should include determination of optimum pitch attitude and forward velocity for ditching in a calm sea as well as entry procedures for the highest sea state to be demonstrated (e.g., the recommended part of the wave on which to land). Procedures for all-engines-operating, one-engine-inoperative, and all-engines-inoperative conditions should be established. However, only the procedures for the most critical condition (usually all engines inoperative) need to be verified by water entry tests.

(ii) The ditching structural design consideration should be based on water impact with a rotor lift of not more than two-thirds of the maximum design weight acting through the center of gravity under the following conditions:

(A) For entry into a calm sea--

(1) The optimum pitch attitude as determined in AC 27.801(b)(1)(i) with consideration for pitch attitude variations that would reasonably be expected to occur in service;

(2) Forward speeds from zero up to the speed defining the knee of the height-velocity (HV) diagram;

(3) Vertical descent velocity of 5 feet per second; and

(4) Yaw attitudes up to 15°.

(B) For entry into the maximum demonstrated sea state--

(1) The optimum pitch attitude and entry procedure as established in AC 27.801(b)(1)(i);

(2) The forward speed defined by the knee of the HV diagram reduced by the wind speed associated with each applicable sea state;

(3) Vertical descent velocity of 5 feet per second; and

(4) Yaw attitudes up to 15°.

(C) The float system attachment hardware should be shown to be structurally adequate to withstand water loads during water entry when both deflated and stowed and fully inflated (unless in-flight inflation is prohibited). Water entry conditions should correspond to those established in paragraphs AC 27.801(b)(1)(ii)(A) and (B). The appropriate vertical loads and drag loads determined from water entry conditions (or as limited by flight manual procedures) should be addressed. The effects of the vertical loads and the drag loads may be considered separately for the analysis.

(D) Probable damage due to water impact to the airframe/hull should be considered during the water entry evaluations; i.e., failure of windows, doors, skins, panels, etc.

(2) Flotation Systems.

(i) Normally inflated. Fixed flotation systems intended for emergency ditching use only and not for amphibian or limited amphibian duty should be evaluated for:

(A) Structural integrity when subjected to:

(1) Air loads throughout the approved flight envelope with floats installed;

(2) Water loads during water entry; and

(3) Water loads after water entry at speeds likely to be experienced after water impact.

(B) Rotorcraft handling qualities throughout the approved flight envelope with floats installed.

(ii) Normally deflated. Emergency flotation systems which are normally stowed in a deflated condition and inflated either in flight or after water contact during an emergency ditching should be evaluated for:

(A) Inflation. The float activation means may be fully automatic or manual with a means to verify primary actuation system integrity prior to each flight. If manually inflated, the float activation switch should be located on one of the primary flight controls. These activation means should be safeguarded against spontaneous or inadvertent actuation for all flight conditions.

(1) The inflation system design should minimize the probability of the floats not inflating properly or inflating asymmetrically. This may be accomplished by use of a single inflation agent container or multiple container system interconnected together. Redundant inflation activation systems will also normally be required. If the primary actuation system is electrical, a mechanical backup actuation system will usually provide the necessary reliability. A secondary electrical actuation system may also be acceptable if adequate electrical system independence and reliability can be documented.

(2) The inflation system should be safeguarded against spontaneous or inadvertent actuation for all flight conditions. It should be demonstrated that float inflation at any flight condition within the approved operating envelope will not result in a hazardous condition unless the safeguarding system is shown to be extremely reliable. One safeguarding method that has been successfully used on previous certification programs is to provide a separate float system arming circuit which must be activated before inflation can be initiated.

(3) The maximum airspeed for intentional in-flight actuation of the float system and for flight with the floats inflated should be established as limitations in the RFM unless in-flight actuation is prohibited by the RFM.

(4) The inflation time from actuation to neutral buoyancy should be short enough to prevent the rotorcraft from becoming more than partially submerged assuming actuation upon water contact.

(5) A means should be provided for checking the pressure of the gas storage cylinders prior to takeoff. A table of acceptable gas cylinder pressure variation with ambient temperature and altitude (if applicable) should be provided.

(6) A means should be provided to minimize the possibility of overinflation of the float bags under any reasonably probable actuation conditions.

(7) The ability of the floats to inflate without puncture when subjected to actual water pressures should be substantiated. A full-scale rotorcraft immersion demonstration in a calm body of water is one acceptable method of substantiation. Other methods of substantiation may be acceptable depending upon the particular design of the flotation system.

(B) Structural Integrity. The flotation bags should be evaluated for loads resulting from:

(1) Airloads during inflation and fully inflated for the most critical flight conditions and water loads with fully inflated floats during water impact for the water entry conditions established under paragraph AC 27.801(b)(1)(ii) for rotorcraft desiring float deployment before water entry; or

(2) Water loads during inflation after water entry.

(C) Handling Qualities. Rotorcraft handling qualities should be verified to comply with the applicable regulations throughout the approved operating envelopes for:

(1) The deflated and stowed condition;

(2) The fully inflated condition; and

(3) The in-flight inflation condition. For float systems which may be inflated in flight, rotorcraft controllability should be verified by test or analysis assuming the most critical float compartment fails to inflate.

(3) Flotation and Trim. The flotation and trim characteristics should be investigated for a range of a sea states from zero to the maximum selected by the

applicant and should be satisfactory in waves having height/length ratios of 1:12.5 for multiengine rotorcraft with Category A engine isolation and 1:10 for all other rotorcraft.

(i) Flotation and trim characteristics should be demonstrated to be satisfactory to at least sea state 4 conditions.

(ii) Flotation tests should be investigated at the most critical rotorcraft loading condition.

(iii) Flotation time and trim requirements should be evaluated with a simulated, ruptured deflation of the most critical float compartment. Flotation characteristics should be satisfactory in this degraded mode to at least sea state 2 conditions.

(iv) A sea anchor or similar device should not be used when demonstrating compliance with the flotation and trim requirements but may be used to assist in the deployment of liferafts. If the basic flotation system has demonstrated compliance with the minimum flotation and trim requirements, credit for a sea anchor or similar device to achieve stability in more severe water conditions (sea state, etc.) may be allowed if the device can be automatically, remotely, or easily deployed by the minimum flightcrew.

(v) Probable rotorcraft door/window open or closed configurations and probable damage to the airframe/hull (i.e., failure of doors, windows, skin, etc.) should be considered when demonstrating compliance with the flotation and trim requirements.

(4) Float System Reliability. Reliability should be considered in the basic design to ensure approximately equal inflation of the floats to preclude excessive yaw, roll, or pitch in flight or in the water.

(i) Maintenance procedures should not degrade the flotation system (e.g., introducing contaminants which could affect normal operation, etc.).

(ii) The flotation system design should preclude inadvertent damage due to normal personnel traffic flow and excessive wear and tear. Protection covers should be evaluated for function and reliability.

(5) Occupant Egress and Survival. The ability of the occupants to deploy liferafts, egress the rotorcraft, and board the liferafts should be evaluated. For configurations which are considered to have critical occupant egress capabilities due to liferaft locations and/or ditching emergency exit locations and floats proximity, an actual demonstration of egress may be required. When a demonstration is required, it may be conducted on a full-scale rotorcraft actually immersed in a calm body of water or using any other rig/ground test facility shown to be representative. The demonstration should show that floats do not impede a satisfactory evacuation.

(6) Rotorcraft Flight Manual. The Rotorcraft Flight Manual is an important element in the approval cycle of the rotorcraft for ditching. The material related to ditching may be presented in the form of a supplement or a revision to the basic manual. This material should include:

(i) The information pertinent to the limitations applicable to the ditching approval. If the ditching approval is obtained in a segmented fashion (i.e., one applicant performing the aircraft equipment installation and operations portion and another designing and substantiating the liferaft/lifevest and ditching safety equipment installations and deployment facilities), the RFM limitations should state "Not Approved for Ditching" until all segments are completed. The requirements for a complete ditching approval not yet completed should be identified in the "Limitations" section.

(ii) Procedures and limitations for flotation device inflation.

(iii) Recommended rotorcraft water entry attitude, speed, and wave position.

(iv) Procedures for use of emergency ditching equipment.

(v) Procedures for ditching egress and raft entry.

AC 27.801-1

SEA STATE CODE

(WORLD METEOROLOGICAL ORGANIZATION)

Sea State Code	Description of Sea	Significant Wave Height Meters	Significant Wave Height Feet	Wind Speed Knots
0	Calm (Glassy)	0	0	0-3
1	Calm (Rippled)	0 to 0.1	0 to 1/3	4-6
2	Smooth (Wavelets)	0.1 to 0.5	1/3 to 1 2/3	7-10
3	Slight	0.5 to 1.25	1 2/3 to 4	11-16
4	Moderate	1.25 to 2.5	4 to 8	17-21
5	Rough	2.5 to 4	8 to 13	22-27
6	Very Rough	4 to 6	13 to 20	28-47
7	High	6 to 9	20 to 30	48-55
8	Very High	9 to 14	30 to 45	56-63
9	Phenomenal	Over 14	Over 45	64-118

NOTES:

(1) The Significant Wave Height is defined as the average value of the height (vertical distance between trough and crest) of the largest one-third of the waves present.

(2) Maximum Wave Height is usually taken to be 1.6 x Significant Wave Height; e.g., Significant Wave Height or 6 meters gives Maximum Wave Height of 9.6 meters.

(3) Winds speeds were obtained from Appendix R of the “American Practical Navigator” by Nathaniel Bowditch, LL.D.; Published by the U.S. Naval Oceanographic Office, 1966.

AC 27.807. § 27.807 (Amendment 27-21) EMERGENCY EXITS.

a. Explanation. The specified emergency exits are as follows:

(1) Quantity, size, and location.

(i) For typical operations.

Passenger Seating Capacity	Main Door (MD) Side	Side Opposite Main Door
1 through 15	MD	(1) 19- by 26-inch ellipse
More than 15	MD + additional exit(s)	(1) 19- by 26-inch ellipse + additional exit(s)

(ii) For overwater operations (if ditching certification is requested), one 19- by 26-inch elliptical exit on each side of the fuselage above the waterline.

(iii) Section 27.807(a) was revised by Amendment 27-21 on November 6, 1984, to remove any reference to the seating capacity in excess of 15 seats. For further information, see Amendment 29-21 which, in part, amended § 29.1 on January 31, 1983.

(2) In addition to quantity and size of exits, the rule specifies the following:

(i) The 19- by 26-inch ellipse portion of the exit is to be unobstructed.

(ii) The exits are to be readily accessible.

(iii) The exits must have a simple and obvious method of opening.

(iv) The exits must be readily located and operated in darkness.

(v) The exits must be protected from jamming by fuselage deformation.

b. Procedures.

(1) The quantity and minimum size of exits will be as specified.

(2) Access to the exits will be provided by aisles, break-over seatbacks, or other features as appropriate. If access is questionable, a demonstration shall be conducted to assess the means of access.

(3) The location and operation of the exits should be evaluated in total darkness.

(4) Protection from jamming is normally provided by clearances between the fuselage exit frame and the exit or by exit designs which are basically insensitive to fuselage deformation. NASTRAN or similar analysis methods have been used in the past to obtain the effects of fuselage deformation on exit clearances during minor crash landings.

AC 27.807A. § 27.807 (Amendment 27-26) EMERGENCY EXITS.

a. Explanation. Amendment 27-26 added § 27.807(d)(3) which requires proof that all rotorcraft ditching configuration exits will also be free of interference from emergency flotation devices, whether stowed or deployed (inflated).

b. Procedures. All of the policy material pertaining to this section remains in effect with the following additions:

(1) Test, demonstration, compliance inspection, or analysis is required to show the “ditching” exits are free from interference from stowed/deployed emergency flotation devices. In the event an analysis is insufficient or a given design is questionable, a demonstrating may be required. The demonstration would consist, as a minimum, of an accurate, full-size replica (or representation) of the rotorcraft and of the flotation devices both before, during, an after their deployment.

(2) The type inspection authorization may be used to perform a detailed compliance evaluation utilizing a full-scale rotorcraft in calm water.

(3) Designs may be accepted “by compliance visual inspection” if location of exit and flotation devices relative to each other ensure that interference is impossible. In this case, a demonstration is unnecessary.

AC 27.831. § 27.831 VENTILATION.

a. Explanation.

(1) This rule specifies minimum ventilation requirements for each passenger and crew compartment. The passenger and crew compartments are required to be free from harmful or hazardous concentration of gases or vapors, and specifically for carbon monoxide, its concentration may not exceed 1 part in 20,000 parts of air during forward flight or hovering in still air.

(2) Failure conditions must also be considered when evaluating the ventilation system, and § 27.1309 is used to cover these aspects. Malfunctions concerning the ventilation system are covered here to make the discussion complete in one paragraph.

(3) This system becomes more significant when engine bleed air is used for conditioning of the passenger and crew compartment’s air. Certain data are necessary in order to analyze properly the bleed air provided under normal and malfunction

conditions. The airframe manufacturer can normally look to the engine manufacturer for a specification of the maximum amount of air that can be extracted and the temperature of the extracted air. The engine manufacturer also normally provides a failure analysis that identifies ways the bleed air can be contaminated and the associated oil flow rates under each failure condition. The oil manufacturers are in a position to provide information regarding breakdown of the oil under different temperature conditions and the impact of that breakdown on the quality of the air being provided to the passenger and crew compartments.

b. Procedures.

(1) The passenger and crew compartments should be monitored under normal operating conditions for the presence of carbon monoxide. A carbon monoxide test kit is normally used for this evaluation. Air is monitored around crew stations, and outlets and different combinations of windows closed/open, heat off/on, air-conditioner off/on, etc., are checked to ensure all conditions are evaluated.

(2) When engine bleed air is used to condition the passenger and crew compartment's air, it should be initially substantiated that under normal operation, the amount of air being extracted does not exceed the limit established by the engine manufacturer. To accomplish this, determine the flight condition that will give the maximum bleed air flow through the flow limiter (venturi). The flow calculations should use this maximum flow condition and should also be made using the maximum tolerance diameter of the venturi throat.

(3) The engine bleed air should also be evaluated under malfunction conditions to determine a worst-case air contamination condition. (A typical worst-case malfunction is for an oil seal to fail in the engine that allows the engine oil supply to be introduced into the airflow.) With information regarding the contaminant, flow rate calculations can be made to predict the contamination levels that will be reached in the passenger and crew compartments and also the associated time duration of passenger and crew exposure. The severity of the exposure to the contaminated air is related to the temperature of the oil when it is introduced into the airflow. For example, synthetic base oils manufactured to MIL-L-7808 or MIL-L-23699 begin to break down into toxic components when the temperature exceeds 300° C (572° F). The oil manufacturers have evaluated this problem and should be in a position to provide data regarding the amount and type of toxic components to be expected, and the effect of introducing those components into the passenger and crew compartments. Therefore, from information supplied by the engine manufacturer, the worst-case air contamination condition can be calculated, and this can be compared with results of the oil manufacturers' tests to determine if the concentrations are harmful or hazardous.

AC 27.833. § 27.833 (Amendment 27-23) HEATERS.

a. Explanation.

(1) Amendment 27-23 added § 27.833 for combustion heaters which is derived from the lead-in paragraph of § 27.859(c) which relates to the fire protection requirements for fuel heaters. Section 27.833 was needed to facilitate the extensive changes made to § 27.859 and to achieve parallel rule construction with Part 29. This will ensure that all combustion heaters will be approved whether as a part of the type design or as a TSO approved combustion heater.

(2) Section 27.833 requires that each combustion heater be approved. The standard contains no provisions regarding functioning of the system, environmental considerations, or malfunctions; therefore, the provisions of §§ 27.1301 and 27.1309 should be used to evaluate those aspects of an installation. The ventilation provisions of § 27.831 should be considered as well as the fire protection and installation provisions of § 27.859.

b. Procedures.

(1) Technical Standard Order, TSO-C20, was issued June 15, 1949, and amended on April 16, 1951, and concerns combustion heaters. If a heater chosen for installation is qualified to the provisions of TSO-C20, it may be approved. If a unit is not TSO qualified, a qualification program for the heater itself in conjunction with the installation should be established. This program under the type design change procedures should be equal or equivalent to provisions of the TSO-C20.

(2) The TSO refers to the SAE Aeronautical Standard, AS 143B, which specifies the use of certain additional devices, design features, air supply considerations, performance tests, safety controls, environmental considerations, and so forth. Compliance with all of the provisions of the Aeronautical Standard should result in an approved unit; however, it will not necessarily result in a satisfactory installation. For environmental considerations, an environmental spectrum more suitable to rotorcraft may be used by referring to the latest version of Document No. RTCA/DO-160, Environmental Conditions and Test Procedures for Airborne Equipment, rather than the older AS 143B. Similarly, other specifications may also be satisfactory for compliance with the standard.

(3) The heater system installation evaluation should also consider functioning of the system based upon the provisions of § 27.1301 (see paragraph AC 27.1301). Section 27.1309(a) is the regulatory basis for also considering environmental conditions (see paragraph AC 27.1309). The expected environmental conditions resulting from the particular rotorcraft installation should be compared to those specified in the TSO. If the conditions derived for § 27.1309 are not met, additional environmental considerations are appropriate. The provisions of § 27.1309(b) should be used to evaluate the possible malfunctions of the installed system. Such an evaluation should be documented in a fault analysis. The air quality provisions of § 27.831 apply since certain standards of “ventilation air quality,” under normal and malfunction conditions, should comply (see paragraph AC 27.831). The provisions of § 27.859 apply. See paragraph AC 27.859 for information.

SUBPART D - DESIGN AND CONSTRUCTION

FIRE PROTECTION

AC 27.853 § 27.853 (Amendment 27-17) COMPARTMENT INTERIORS.

a. Explanation.

(1) Crew and passenger compartments must have materials that are at least flash resistant or flame resistant as prescribed for the application cited in the standard.

(2) Whenever smoking is allowed, self-contained, removable ashtrays must be provided as stated. A placard or placards, if needed, may be used to prohibit smoking at all times in the crew and passenger compartment. If smoking is allowed, illuminated “no smoking” signs are required. The signs shall meet prescribed standards for passenger compartments that are separate from the flightcrew. Integral crew and passenger compartments (of smaller rotorcraft) do not require illuminated signs since oral commands or instructions from the flightcrew are sufficient.

(3) Amendment 27-17 revised paragraph (c) of § 27.853 by adding the standards for the “no smoking” illuminated signs that must be controllable by the flightcrew. Amendment 29-18 added the same standards for FAR Part 29 transport rotorcraft. The standard requires at least one illuminated sign for use in daylight as well as night in passenger compartments that are separate from the crew compartment. The sign shall be legible to each seated passenger. If forward and aft facing seats are installed, signs for each seat orientation may be needed as prescribed. Section 29.853(c) of Amendment 29-18 is the same standard as § 27.853(c) of Amendment 27-17.

(4) Advisory Circular 23-2, Flammability Tests, August 20, 1984, provides historical background of the regulatory standards for flash resistant, flame resistant, fire resistant, and fireproof materials. The procedures in AC 23-2 may be used for FAR Part 27 standards. Section 27.853 does not impose standards for mandatory use of self-extinguishing materials. Nevertheless, the FAA/AUTHORITY encourages and recommends use of self-extinguishing interior materials that comply with § 29.853 of Amendment 29-17.

(5) Flammability standards for certain electrical wires or cables are specified in § 27.1365. See paragraph AC 27.1365 for information about electrical wires.

b. Procedures.

(1) Aircraft interior materials including consoles, cabinets, etc., are subject to the standards.

(2) Advisory Circular 23-2 may be referred to in preparation of test proposals for flammability tests of interior materials.

(3) A placard prohibiting smoking may be used if ashtrays are not provided. If ashtrays are provided, an adequate number shall be provided, and the installation must have an inner fire resistant liner to close off the ashtray cavity or receptacle when the ashtray is removed.

(4) All illuminated "no smoking" sign or signs must be used when prescribed. Flightcrew must be able to control illumination of the signs.

(5) If a hand-held fire extinguisher is installed to comply with an operating rule, Advisory Circular 20-42C, Hand Fire Extinguishers for Use in Aircraft, contains acceptable information about hand-held fire extinguishers.

AC 27.855 § 27.855 CARGO AND BAGGAGE COMPARTMENTS.

a. Explanation.

(1) Cargo and baggage compartments must be constructed of or lined with--

(i) Fire resistant material; or

(ii) Flame resistant material for compartments readily accessible to the crew while in flight.

(2) A liner or a separately constructed compartment shall protect the aircraft structure from significant loss of strength in the event of a compartment fire.

(3) Whenever essential or critical controls, wiring, lines, etc., are located in a compartment, they must be protected as prescribed.

(4) For historical reference, this design standard was adopted in 1953 by Amendment 6-4 to CAR Part 6 for normal category rotorcraft and adopted into FAR Part 27. The expressed interest, paraphrased from the preamble for the amendment, is to provide protection from a compartment fire to a degree which will ensure that a controlled autorotational landing can be made during a period of at least 5 minutes after start and detection of a fire. No distinction was made for twin-engine rotorcraft. A distinction was made between accessible and inaccessible compartments.

(5) It is recommended that tiedown straps or nets, if installed, should be made of material that is at least flame resistant.

(6) Reference is made to § 27.853 and paragraph AC 27.853 for flammability standards of certain materials.

b. Procedures.

(1) For a compartment accessible in flight, a flame resistant liner, box, or closure of the compartment is required. For an inaccessible compartment, a fire resistant liner, an aluminum inner skin, box, or closure of the compartment is required. Advisory Circular 23-2, Flammability Tests, provides information about material flammability tests.

(2) Only fire resistant material may be used in inaccessible compartments. Carpets and wall coverings may not be used.

(3) Flame resistant materials may be used on floors, walls, and ceilings of accessible compartments.

(4) Although not specified in the standards, it is recommended that tiedown nets or straps comply with the self-extinguishing flammability standards of § 29.853(a)(3). Cargo compartment blankets or covers should comply with the flammability standards of § 29.853(a)(2). However, it is acceptable to use tiedown equipment that meets the flame resistant material standard.

(5) It is recommended that compartments use design features that seal the compartment and prevent airflow into (or out of) the compartment. The objective is to limit the air supply to a potential fire.

(6) Controls, wiring, equipment, and accessories should not be routed through, mounted in, or exposed to the compartment. If these items, as described in § 27.855(b), are in the compartment, they should be protected by a cage or rigid housing adequate to protect the items. To maintain the compartment integrity for fire containment, it may be necessary to separate these items from the compartment by an appropriate fire resistant or flame resistant housing or enclosure.

AC 27.859 § 27.859 (Amendment 27-23) HEATING SYSTEMS.

a. Explanation. This regulation ensures that onboard heating systems (of all type designs) are safe during normal and survivable emergency operations. Thus, as a minimum, each heating system type design must meet the applicable requirements of § 27.859.

b. Definitions.

(1) Backfire. An improperly timed detonation (or explosion) of a fuel mixture which results in higher than normal temperatures and pressures.

(2) Reverse flame propagation. An event that occurs when the flame from a controlled combustion process (such as a heater) goes in an abnormal path (i.e., either a reverse or different path than the intended path) as a result of a change in internal

pressure or internal pressure gradient (e.g., a backfire) from a detonation or a similar event.

(3) Safe distance. A maximum flow length dimension determined from the thermodynamics of a worse case flow reversal (backfire) and the local heater system geometry.

(4) Heater zone (or region). A geometric zone defined by the heater type, heater size, location of heater system components, and the maximum safe distance determined under (3) above. The heater system components may affect the heater zone's size if they are closely located to the heat source. For example a heater fuel tank would not be part of the heater zone if it were located far away from the zone boundary; however, if it were adjacent or close to the boundary, it would be included in the heater zone.

(5) Fireproof. Fireproof is defined in § 1.1 "General Definitions."

(6) Severe Fire. The following thermodynamic definitions are based on AC 20-135, "Powerplant Installation and Propulsion System Component Fire Protection Test Methods, Standards, and Criteria" and on the definitions in § 1.1 for fire resistant and fireproof materials. These definitions are provided for analytical purposes. A severe fire, when used with respect to fireproof materials, is one which reaches a steady state temperature of 2,000 ±150° F for at least 15 minutes. A severe fire, when used with respect to fire resistant materials, is one which reaches a steady state temperature of 2,000 ±150° F for at least 5 minutes.

(7) Hazardous accumulation of water or ice. An accumulation of water or ice that causes a device to not perform its intended function in either normal operation or a survivable emergency situation.

c. Procedures. When suitable data is available, the heating system design should be thoroughly reviewed to determine which system components and arrangements must comply with each subsection of § 27.859. The method-of-compliance relative to each subsection of § 27.859 should then be determined. Acceptable, but not the only, methods of compliance are discussed on a section-by-section basis as follows.

(1) For compliance with § 27.859(a), mechanical devices such as shrouds or barriers should be used to create a double walled (fail-safe) condition, i.e., two equal barrier failures must occur to allow carbon monoxide to mix with cabin air. Phased inspections to ensure continued airworthiness should be considered, as well. The purpose of these measures is to eliminate any system leakage that would allow carbon monoxide (a poisonous gas) to enter occupied areas, incapacitate the crew or passengers and cause a crash. Regardless of the method-of-compliance chosen, periodic checks should be performed during certification using carbon monoxide detection equipment to certify the leak-free integrity of the system. Several such checks

should be done during flight test, especially after rigorous maneuvers, to ensure no leakage.

(2) For compliance with § 27.859(b), heat exchangers should meet the requirements of paragraph AC 27.1123, and be readily inspectable either by complete disassembly or by use of other equivalent design maintenance provisions (such as removable inspection covers). Inspectability should be demonstrated during certification by a design review, an inspection demonstration or a combination.

(3) For compliance with § 27.859(c), combustion heater designs, their installations and their heater zones must be identified and thoroughly evaluated. The most direct method of compliance for the heater, itself, is to procure units that already have internal design features that meet the relevant requirements of this section; otherwise, design features must be provided and evaluated during certification that meet these same requirements. Several combustion heaters are approved under TSO-C20 provides the procurement sources and the detailed approval standards for these combustion heaters. Each heater, its installation, and its heater zone should be reviewed against the criteria of §§ 27.1183, 27.1185, 27.1189, and 27.1191 (reference paragraphs AC 27.1183, AC 27.1185, AC 27.1189, and AC 27.1191) to ensure compliance. Next, the fire detector installation drawings and specifications should be reviewed for each heater region. The review should consider all reasonable hazards and failure modes of the heater and the detection system. If not previously TSO approved the detectors should be evaluated during the overall system certification effort. The drainage and venting system for each heater installation should be reviewed to ensure that areas of fuel or fuel vapor collection are properly drained or vented. The capacity of each drain or vent should be determined and, unless impracticable, the flow capacity should be a minimum of 3-to-1 over the worst case leakage anticipated (including the adverse effects of surface tension). Finally, the drainage and ventilation systems should be reviewed to ensure that discharges do not create external hazards by entering or contacting external ignition sources such as engine inlets and hot exhausts. If an accurate determination cannot be made by a design review, ground and/or flight test work with dyed, inert fluids or vapors should be conducted to accurately display discharge patterns.

(4) For compliance with § 27.859(d), the ventilating air duct design should be reviewed to determine what ducts are routed through heater zones. Once this has been determined, each duct section running through the heater zone should be made fireproof by either using a fireproof shroud around the existing duct or by using fireproof material for the duct wall.

(5) For compliance with § 27.859(e), any design using combustion air ducts should be reviewed to ensure that the ducts are either made from fireproof material or shrouded with a fireproof shroud over a safe distance (see definition). The safe distance should be determined analytically, by test, or a combination, if the analytical results are not conclusive. The design should be reviewed to ensure that combustion air ducts are not connected to the ventilating air stream, except when an equivalent

safety finding can be made that shows backfires or reverse burning cannot induce flames or fumes into the ventilating air stream under any failure condition or malfunction of the heater or its associated components. Such a finding should require analysis, testing, or a combination for a proper determination.

(6) For compliance with § 27.859(f), the design and installation of all standard control components, control tubing and safety controls should be reviewed to determine the probable points of water or ice accumulation (e.g., sumps, rough surfaces, joints, etc.) If a design review cannot accurately determine these accumulation points, then bench tests and flight tests should be conducted for proper determination. Once these points are identified, the ability of the effected part (or parts) to perform its intended function when water or ice has fully accumulated must be determined for both normal and failure conditions. If the part (or parts) either has not lost its ability to function: has lost only part of its ability to function; or has lost all of its ability to function; and the entire system's function is not impaired, then nothing further should be required. However, if the overall system's function is hazardously impaired or lost, as a result of water or ice accumulation on a part (or parts), then rectifying design improvements should be made prior to final approval. These improvements should either alter the part's environment (e.g., relocation, enclosure, insulation, etc.) or eliminate the hazardous accumulation of water or ice (e.g., provide drainage, better sealing, better location, different surface finish, etc.).

(7) For compliance with § 27.859(g), combustion heaters, if used, must have separate, independent safety controls from their standard controls (e.g., air temperature, air flow, fuel flow, etc.) which are remotely located in case of a heater fire, are operable by the crew and automatically shut off the ignition and fuel supply when a hazardous condition exists (as defined by § 27.859(g)). These separate safety controls must comply with § 27.859(g)(1), must keep the heater off until restarted by the crew or ground maintenance, and must warn the crew when an essential heater is automatically shut down. The safety control system design should be thoroughly reviewed and tested to ensure that it complies and that no hazardous failure modes exist.

(8) For compliance with § 27.859(h), each combustion and ventilating air intake's location should be identified, reviewed, and tested to ensure that no flammable fluids or vapors can enter the heater system, ignite and create a fire. If a combustion or ventilating air intake's location is critical or questionable, it should be relocated, shielded, drained, or other equivalent means provided to eliminate the potential fire hazard. If engineering analysis and evaluation are not adequate to make an acceptable safety finding, testing using dyed, inert, leaked fluids or vapors should be conducted.

(9) For compliance with § 27.859(i), each heater exhaust system design should be reviewed, tested, or a combination to ensure proper compliance with § 27.1121 and § 27.1123 (reference AC paragraphs AC 27.1121 and AC 27.1123, respectively). Each exhaust shroud should be sealed to ensure that leaked flammable fluids or vapors do not contact the hot exhaust and cause a fire. The seal design should be reviewed to ensure that the sealing material is fireproof, is chemically compatible with the relevant

fuels and vapors, is durable and is functionally adequate. If the design review is not conclusive for compliance purposes, then the seal system should be bench tested under pressure while undergoing critical service loads and motions to ensure no leakage occurs. An analysis should be conducted to determine the structural effects on the exhaust system of the worse case restricted backfire (typically a shock wave analysis can be used to determine the peak internal pressure and, the resultant load on the exhaust system.) If structural failure would occur, based on the analysis, either the backfire restriction should be reduced or the exhaust design should be structurally improved to eliminate the failure.

(10) For compliance with § 27.859(j), each heater's fuel system design must be reviewed to ensure that compliance with the powerplant fuel system requirements of Part 27 that are necessary for safe operation to be achieved. An equivalent safety finding should be made if an application is received that requests partial compliance or non-compliance with the powerplant fuel system requirements of Part 27. The finding should ensure that the safety intent of § 27.859(j) is achieved. Analysis, engineering evaluation, testing, or a combination should be used to substantiate the heater fuel system design. Heater fuel system components that, by leakage or other failures, can induce flammable fluids or vapors into the ventilating air stream should be shrouded by drainable, fireproof shrouds.

(11) For compliance with § 27.859(k), the drain system design should be reviewed to identify parts that may be subjected to high temperature and parts that may be subjected to hazardous ice accumulation in service. The high temperature parts should be evaluated using the methods of compliance for heater exhausts (reference paragraph AC 27.859b(9), above and paragraph AC 27.1123). Drains that would be stopped up from ice accumulation should be protected by relocation, size, shields, heating, or a combination to ensure hazardous fluids and vapors are properly drained away.

AC 27.861 § 27.861 FIRE PROTECTION OF STRUCTURE, CONTROLS, AND OTHER PARTS.

a. Explanation.

(1) As stated in the rule, parts essential to a controlled landing that would be affected by a powerplant fire are to be protected so they can perform their essential functions for at least 5 minutes under any foreseeable powerplant fire condition.

(2) To achieve the objective of the rule, essential parts of the rotorcraft as defined by the rule are to be isolated from a powerplant fire by a firewall (§ 27.1191) or must be protected so they can perform their essential functions for at least 5 minutes under any foreseeable powerplant fire condition.

(3) Insufficient protection to provide enough time for a controlled landing would represent an unsafe feature or characteristic for the rotorcraft design.

(4) Section 27.1193(d) requires each cowling and engine compartment covering to be at least fire resistant. Also, § 27.1193(e) requires that each part of the cowling or engine compartment covering, subject to high temperature due to its nearness (proximity) to exhaust system parts or exhaust gas impingement, must be fireproof.

(5) In addition, § 27.1194 requires that all surfaces aft of and near powerplant compartments, other than tail surfaces not subject to heat, flames, or sparks emanating from a powerplant compartment, be at least fire resistant.

b. Procedures.

(1) If each part described in the rule is isolated completely by firewalls, compliance is obtainable.

(2) If each part described by the rule is made of fireproof material, such as steel, compliance is obtained.

(3) If any part described by the rule does not comply with AC 27.861b(1) or (2), it shall be proven that it will perform its function under the prescribed conditions. Compliance may be demonstrated by the following criteria:

(i) The parts shall have a positive margin of safety for the appropriate flight and landing condition, including appropriate engine power conditions, under any foreseeable powerplant fire condition. The time interval under consideration here is the time necessary to complete an emergency descent (as described in the flight manual) and landing from the maximum operating altitude for which certification is requested. In no case is the total time interval to be less than 5 minutes.

(ii) The factors affecting the time interval should include the maximum height above the terrain, the maximum operating altitude, the flight manual recommendations for rate of descent, and a reasonable time for recognizing a powerplant fire.

(iii) The factors affecting the change in physical characteristics (strength primarily, but stiffness may also be a factor) of the parts are the temperature of the part, time interval at the elevated temperature, size, and heat absorption or rejection.

(iv) The factors affecting the temperature of the part are location and distance from the fire and flames and temperature of the flames (2,000° F ±50° F should be used unless proven to be inapplicable).

(v) The rule requires substantiations for any foreseeable powerplant fire condition. Each rotorcraft design is unique and an evaluation of each design is necessary to establish the fire and flight conditions under consideration.

(vi) A very brief and simple example of compliance noted here may be helpful. This example pertains to a single-engine rotorcraft with the engine mounted on top at the fuselage centerline. The engine is supported by all steel tubular mounts. The fuselage panel serves as a work deck as well as a firewall. A 15-minute duration is appropriate for this design. A representative panel of the firewall (deck) skin may be subjected to the autorotational flight loads and the landing load. A flame from an appropriate-sized burner, measuring 2,000° F ±50° F at the skin surface, should impinge on the loaded panel for 15 minutes. The panel may deform but must remain intact and sustain the appropriate load. The flame should not penetrate the panel skin.

(vii) Other rotorcraft designs may have engines located on top of the fuselage under the main rotor. If cowls or firewalls do not isolate the rotors and essential controls, it must be determined by a rational analysis or by temperature measurement that the rotor and essential controls will perform their functions. Air flow through the rotor and factors noted in paragraphs AC 27.861b(3)(ii), (3)(iii), and (3)(iv) are important to an analysis.

AC 27.861A § 27.861 (Amendment 27-26) FIRE PROTECTION OF STRUCTURE, CONTROLS, AND OTHER PARTS.

a. Explanation.

(1) Amendment 27-26 revised the regulation to allow use of parts made from standard fireproof materials of known acceptable dimensions in areas affected by powerplant fires without further proof or qualification. Previously, the standard imposed a performance criteria regardless of the materials and part dimensions used.

(2) “Fireproof” and “fire resistant” are defined in FAR Part 1, § 1.1.

b. Procedures.

(1) A part of acceptable geometry made of steel, or another fireproof material, may be used to comply with the standard.

(2) A material system, panel, or assembly would be equivalent to steel provided it successfully completes the flammability tests described in paragraph AC 27.861b(3)(vi), for Category B rotorcraft adjusted for the time period appropriate to the rotorcraft application.

(3) It is appropriate to further define “fire resistant.” A material system, panel, or assembly would be equivalent to aluminum (fire resistant) if it successfully completes the following flammability test. Locate a specimen (approximately 8 inches square) of the material system panel, assembly, or part at approximately a 45° angle to a horizontal line. Apply the limit or normal operating load. Impinge a 2000 ±150° F (1093 ± 83°C) flame on the article for at least 5 minutes duration. Flame penetration of

the test article is not allowed. In addition, the part or component should be able to perform its intended function, as installed, during and after the test.

AC 27.863 § 27.863 (Amendment 27-16) FLAMMABLE FLUID FIRE PROTECTION.

a. Background.

(1) The development of § 27.863 can be traced through CARs 6.485 and 6.486, and subsequent Amendment 27-16.

(2) Investigation of several accidents disclosed evidence of in-flight fires caused by leakage of flammable fluids to ignition sources. The revisions to § 27.863 adopted by Amendment 27-16 require significantly more attention to overall fire protection and prevention.

b. Explanation.

(1) Prior to Amendment 27-16, this rule only required either a means to prevent ignition of flammable fluids or vapors or a means to control any resulting fire. Isolation of flammable fluids and vapors from ignition sources by shrouding or sealing was the normal method of compliance. With Amendment 27-16, the rule further requires the assumption that these means fail or are ineffective and a fire does occur. Means to minimize the consequence of these fires must be provided. Specifically identified considerations must include the flammability of any combustible or absorbing materials, electrical faults, malfunction of protective devices, and so forth.

(2) The rule does not require the entire rotorcraft to be a “designated fire zone.”

c. Methods of Compliance.

(1) To minimize the probability of ignition of fluids and vapors after single failure of a component or systems, the following methods may be used:

(i) Shroud and drain flammable fluid systems (including steel fluid lines, fittings, etc.) and provide the systems with fuel and vapor seals with respect to potential ignition sources (electrical wiring and equipment, hot bleed air lines, etc.).

(ii) Provide other effective separation, ventilation, or overheat shutdown devices, etc., to preclude ignition.

(iii) Ensure that electrical equipment in the areas subject to flammable fluids and vapors is either hermetically sealed or has been tested and shown to be free of ignition capability. Paragraph AC 27.1309 describes acceptable guidance for such laboratory testing.

(iv) Place a restricting orifice in fluid pressure lines routed to instruments and transducers.

(v) Ensure fluid lines are not located so as to be subject to abrasion during normal operations. Cargo compartments should be evaluated for potential line damage due to cargo movement.

(2) To minimize hazards if ignition occurs:

(i) Provide fireproof designs, firewall isolation, or equivalent means for critical structure, equipment, and personnel areas.

(ii) Consider fire detection, extinguishment, shutoff valves, fire suppression systems, etc.

(3) In considering compliance, the actual protective measures may be related to the situation, considering the quantity and flammability characteristic of the fluid, the fire damage tolerance of the area, and the means available to the crew to minimize hazards from the fire. If action by the crew is necessary, a quick acting means (not necessarily fire detectors) must be provided to alert the crew in the event of a fire. Details of any action required by the crew should be included in the Rotorcraft Flight Manual.

(4) Compliance with § 27.863(d) requires, a minimum, type design data defining each area where flammable fluids or vapors might escape.

SUBPART D - DESIGN AND CONSTRUCTION

EXTERNAL LOAD ATTACHING MEANS.

AC 27.865. § 27.865 (Amendment 27-11) EXTERNAL LOAD ATTACHING MEANS.

a. Explanation.

(1) If certification for external load operations is requested, the rule requires that the external load attaching means be substantiated by test or analysis for a limit static load equal to or greater than 2.5 times the maximum external load for which certification is requested. The factor of 2.5 times the maximum external load was established as a minimum strength requirement by Part 133 operations to account for loading effects of sling-load angles up to 30° from the vertical. Allowance for reducing the 30° angle is provided if substantiated.

(2) The rule requires that a quick-release device be installed on one of the pilot's primary controls so the pilot can quickly release the external load during an emergency situation. In addition, a backup manual mechanical control for the quick-release device is required to be readily accessible to either the pilot or another crewmember.

(3) The rule requires appropriate placards or markings stating the maximum authorized external load.

b. Procedures.

(1) The maximum external load for which authorization is requested should not exceed the rated capacity of the quick-release device. The quick-release device should be strength tested (with FAA/AUTHORITY witness) if it is not produced to a recognized industry or military standard.

(2) Substantiation of external loading requirements must include any direction making an angle of 30° (with the exception of directions having a forward component). (reference § 27.865(a).)

(i) The sling-load angle (i.e., the angle between the vertical direction and the sling-load cable supporting the external load) should not exceed an angle of 30° to minimize the cable tension load.

(ii) The 30° angle may be reduced if an operating limitation is established limiting external load operations to such angles for which compliance has been shown or if the reduced angle cannot be exceeded in service. The lesser angle should be substantiated by flight testing.

(3) The external load releasing system is specified to include a quick release device installed on one of the pilot's primary controls. It is usually installed on the cyclic stick to allow the pilot to release the load with minimum distraction after maneuvering the load into the release position.

(4) A manual mechanical control for the quick-release device is specified to be installed and be readily accessible to the pilot or to another crewmember. A sufficient amount of slack should be provided in the control cable to permit complete cargo movement without tripping the cargo release.

AC 27.865A. § 27.865 (Amendment 27-26) EXTERNAL LOAD ATTACHING MEANS.

a. Explanation. Amendment 27-26 added two requirements to § 27.865:

(1) Section 27.865(a) is clarified to allow use of a design factor less than 2.5g's, for rotorcraft load combinations A, B, and C non-human external cargo applications provided the lower load factor is not likely to be exceeded by virtue of the rotorcraft characteristics and capability. That is, the rotorcraft design factors may be used for the cargo device system.

(2) Section 27.865(d) was added to clarify and specify the fatigue requirements for the external cargo attaching means.

b. Procedures. All of the policy material pertaining to this section remains in effect with the following additions:

(1) For § 27.865(a), if a design limit load factor less than 2.5g's is requested, the applicant should provide a rational analysis and/or a flight operations data base that clearly shows that the load factor requested is unlikely to be exceeded in service.

NOTE: § 27.337(b) requires use of 2.0 g's as a minimum.

(2) § 27.865(d), all failures of the cargo attaching means (and the associated critical components) that are likely to be hazardous to the rotorcraft should be identified by an acceptable means, such as a Failure Mode Effect Analysis (FMEA). The critical components associated with these failure modes should receive a fatigue analysis and/or test to ensure that the likelihood of a failure occurring is minimized. In the majority of cases, an analysis using the methods of AC 20-95, "Fatigue Evaluation of Rotorcraft Structure", will be sufficient. If any component has a service life and/or mandatory inspection these components and each mandatory life should be identified, approved, and placed in the airworthiness limitations section of the maintenance manual or Instructions for Continued Airworthiness. See paragraph AC 27.1529 for information on these manuals.

AC 27.865B. § 27.865 (Amendment 27-36) EXTERNAL LOAD ATTACHING MEANS.

Advisory material for rotorcraft load combination A, B, and C safety requirements (External Loads) for Amendment 27-36 is located in Miscellaneous Guidance (MG) 12 of this AC.

SUBPART D - DESIGN AND CONSTRUCTION

MISCELLANEOUS (DESIGN AND CONSTRUCTION)

AC 27.871 § 27.871 LEVELING MARKS.

a. Explanation. Reference marks are required for leveling the rotorcraft on the ground. These marks are necessary for accurate determination of weight and balance effects, particularly after modifications to the basic rotorcraft.

b. Procedures.

(1) Reference marks are sometimes provided in pairs, one high in the cabin and one low. The plumb weight is suspended from the high mark by an appropriate mechanical attachment, and the lower mark is used to level the rotorcraft by centering the plumb weight. The lower reference mark should be a raised or depressed target symbol and shall be applied to a permanent structural component or permanently attached plate in a readily accessible location. Seat tracks, floors, or door sills which are attached with permanent fasteners are typical locations.

(2) Horizontal reference marks, for support of bubble levels, may also be used, particularly for smaller rotorcraft.

AC 27.873 § 28.873 BALLAST PROVISIONS.

a. Explanation.

(1) This rule requires that ballast provisions prevent inadvertent ballast shifting while in flight or as a result of a landing. Shifting of the ballast may cause a hazardous change in the center of gravity thereby affecting rotorcraft controllability.

(2) Other rules noted here allow removable and fixed ballast and require markings or placards to prevent overloading the ballast installation.

(i) Section 27.29 specifies that the rotorcraft empty weight will include any fixed ballast. Section 27.31 allows the use of removable ballast to comply with the flight requirements. However, ballast may not be adjusted (moved, reduced, or increased) in flight.

(ii) Section 27.1541 requires conspicuous and durable markings or placards. Section 27.1557 requires placards stating allowable maximum weight, distributed loading, if necessary, and other appropriate limitations for ballast installation.

(3) Section 27.1583(c) concerns Rotorcraft Flight Manual instructions and information about removable ballast or loading information. The instructions must be

included in the operating limitations section of the flight manual to allow ready observance of the limitations.

b. Procedures.

(1) The ballast installation may be substantiated by analysis or by static test. The design ultimate load may be derived from flight, landing, or minor crash conditions load factors specified in the rules. Substantiation by analysis will require use of the fitting factor prescribed by § 27.625 where appropriate. If static tests are to be conducted, a test plan should be prepared, submitted for evaluation, and agreed upon prior to the test.

(2) Ballast installations in the aft part of the fuselage and tail boom may be subject to significant landing condition angular inertia load factors as well as the usual linear load factors.

(3) Substantiation methods and procedures acceptable for the airframe substantiation may be used for the ballast installation as well.

(4) Removable ballast will require attention to ensure the ballast is secured easily and properly and will remain secured under the appropriate ballast design load factor requirements. The flight manual instructions should be evaluated for compliance with § 27.1583(c) by flight test and airframe personnel.

(5) The installation must be designed and placarded or marked for the maximum allowable ballast load and for other appropriate loading limits. Normally compliance with § 27.1541 is accomplished with a drawing review by airframe personnel along with a MIDO or FSDO compliance and conformity inspection. An additional compliance inspection by airframe personnel can be conducted if desired.